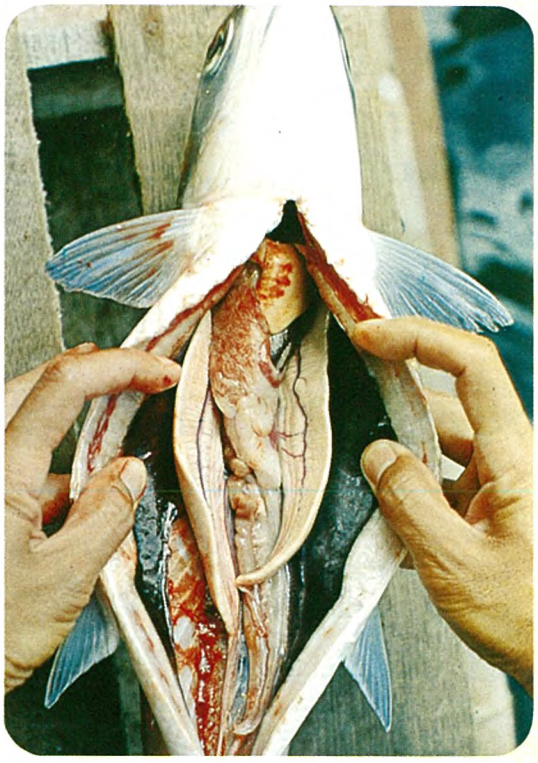
Annual Report 1980

SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER

AQUACULTURE DEPARTMENT

1

2



3

5

(1) Trainees observe prawn hatchery operations at the SEAFDEC Aquaculture Department's Batan substation. (2) Floating circular cages at Igang, Guimaras Is. where milkfish have sexually matured and spontaneously spawned in captivity. (3) Dissected male mature sabalo grown in captivity at the Igang substation. (4) The ovaries from the dissected female milkfish which matured in floating cage at Igang. Fecundity of the fish was estimated at 545,000-976,000. (5) Poultry houses built over brackishwater ponds at the Leganes Research Station. (6) The Binangonan Research Station at Tapao Point, Laguna de Bay.

4

6

CONTENTS

SEAFDEC Council of Directors

Commander Swarng Charernphol, RTN *Chairman*	Director-General Department of Fisheries Ministry of Agriculture and Cooperatives Thailand
Mr. Felix R. Gonzales	Director Bureau of Fisheries and Aquatic Resources Philippines
Tengku Dato Ubaidillah bin Abdul Kadir	Director-General Fisheries Division Ministry of Agriculture Malaysia
Dr. Siew Teck Woh	Director Primary Production Ministry of National Development Singapore
Mr. Shizuo Yamauchi	Deputy Director-General Ministry of Agriculture, Forestry and Fisheries Japan

SEAFDEC Secretariat

Dr. Deb Menasveta *Secretary-General*	Chief Training Department
Dr. Shigeaki Shindo *Deputy Secretary-General*	Deputy Chief
Mr. Hooi Kok Kuang	Chief Marine Fisheries Research Department
Mr. Inazo Tanaka	Deputy Chief
Dean Rogelio O. Juliano	Chief Aquaculture Department
Mr. Kunio Katsutani	Deputy Chief

AQD Senior Personnel

OFFICE OF THE CHIEF

Rogelio O. Juliano, *Chief*
Kunio Katsutani, *Acting Chief*

OFFICE OF THE DEPUTY CHIEF

Kunio Katsutani, *Deputy Chief*

External Affairs

Yong Chan Kim, *External Affairs Officer*
Natividad Millar, *Administrative Asst.*
Virgilia Sulit, *Project Development Coordinator*
Virginia Relampagos, *Accountant*

Internal Audit

Ben de los Reyes, *Internal Auditor*
Romeo Obispo, *Internal Auditor*
Ma. Teresa Aguinaldo, *Asst. Internal Auditor*
Antonio Rubin, Jr., *Asst. Internal Auditor*

TIGBAUAN RESEARCH STATION

Chhorn Lim, *Station Head*

Fish Hatchery

Jesus Juario, *Researcher, Project Leader*
Flor Lacanilao, *Endocrinologist*
Shiro Hara, *Japanese Expert*
Clarissa Marte, *Research Associate*
Antonio Villaluz, *Researcher*
Marietta Duray, *Research Associate*

Crustacean Hatchery

Jurgenne Primavera, *Researcher, Project Leader*
Rolando Platon, *Researcher*
Yoshitetsu Nukiyama, *Japanese Expert*
Porfirio Gabasa, Jr., *Research Associate*

Seafarming

Wilfredo Yap, *Researcher, Project Leader*
Porfirio Manacop, *Researcher*
Virgilio Uyenco, *Researcher*
Adriano Atencio, *Researcher*

Nutrition and Feed Development

Felicitas Pascual, *Researcher, Project Leader*
Chhorn Lim, *Researcher*
Lita Benitez, *Researcher*

Ecology

Hiroshi Motoh, *Japanese Expert, Project Leader*
Shigeru Kumagai, *Japanese Expert*
Noel Solis, *Research Associate*
Hermenegildo Sitoy, *Research Associate*
Prasit Buri, *Research Associate*

Natural Food

Elsie Tech, *Research Associate, Project Leader*
Cesar Villegas, *Researcher, OIC*
Einstein Laviña, *Research Associate*
Eva Aujero, *Research Associate*
Nepheronia Jumalon, *Research Associate*

Pathology

Gilda Lio-Po, *Research Associate, Project Leader*
Rogelio Gacutan, *Research Associate*

Aquaculture Engineering

Pastor Torres, Jr., *Project Leader*
Rufino Ignacio, *Researcher*
Oseni Millamena, *Research Associate*
Rodolfo Tolosa, *Research Associate*

Batan Substation

Porfirio Gabasa, Jr., *Substation Head*

Igang Substation

Flor Lacanilao, *Substation Head*

Himamaylan Substation

Edgar Gargantiel, *Substation Head*

Zamboanga Substation

Pedro Gutierrez, *OIC*

Centralized Analytical Laboratory

Lita Benitez, *Supervisor*

Research Information Service

Ma. Teresa Corpus, *Supervisor*
Rudy Tan, *Consultant in Statistics*

Microtechnique

Clarissa Marte, *Supervisor*

Repair and Maintenance

Eduardo Hidalgo, *Supervisor*

LEGANES RESEARCH STATION

Arsenio Camacho, *Researcher, Station Head*
James Norfolk, *Visiting Researcher*
Masanori Suemitsu, *Japanese Expert*
Melchor Lijauco, *Researcher*
Pascual Acosta, *Researcher*
Salvacion Palma-Gil, *Research Associate*
Dante Gerochi, *Research Associate*
Dan Baliao, *Research Associate*
Renato Bernal, *Administrative Asst.*

BINANGONAN RESEARCH STATION

Alfredo Santiago, Jr., *Researcher, Station Head*
Julia Pantastico, *Researcher*
Antonio Bautista, *Researcher*
Alejandro Santiago, *Research Associate*
Socorro Castro, *Research Associate*
Elvira Baluyot, *Research Associate*
Corazon Santiago, *Research Associate*
Artemio Bernardino, *Research Associate*
Jovenal Lazaga, *Administrative Officer*
Virgilio Muñoz, *Accountant*

SEAFDEC INSTITUTE OF AQUACULTURE

Joseph Madamba, *Director*
Thomas Flores, *Deputy Director*
Jose Agbayani, Jr., *Head, Training & Extension*
Emilio Gapit, *Librarian*
Emmanuel Encarnacion, *Aquaculture Economist*
Pedro Bueno, *Communications Officer*

GENERAL AFFAIRS DIVISION

Renato Agbayani, *OIC*
Alejandro Lim, Jr., *Financial Officer*
Thelma Siglos, *OIC, Finance Office*
Ignacio Salutan, *Accountant*
Pablito Ynot, *Budget Officer*
Orlando Yu, *Supt., PPO*
Angelito Vizcarra, *Asst. Supt., PPO*
Andresito Degilla, *OIC, Asst. Supt., PPO*
Julia Ana Jaranilla, *OIC, Auxiliary Services*

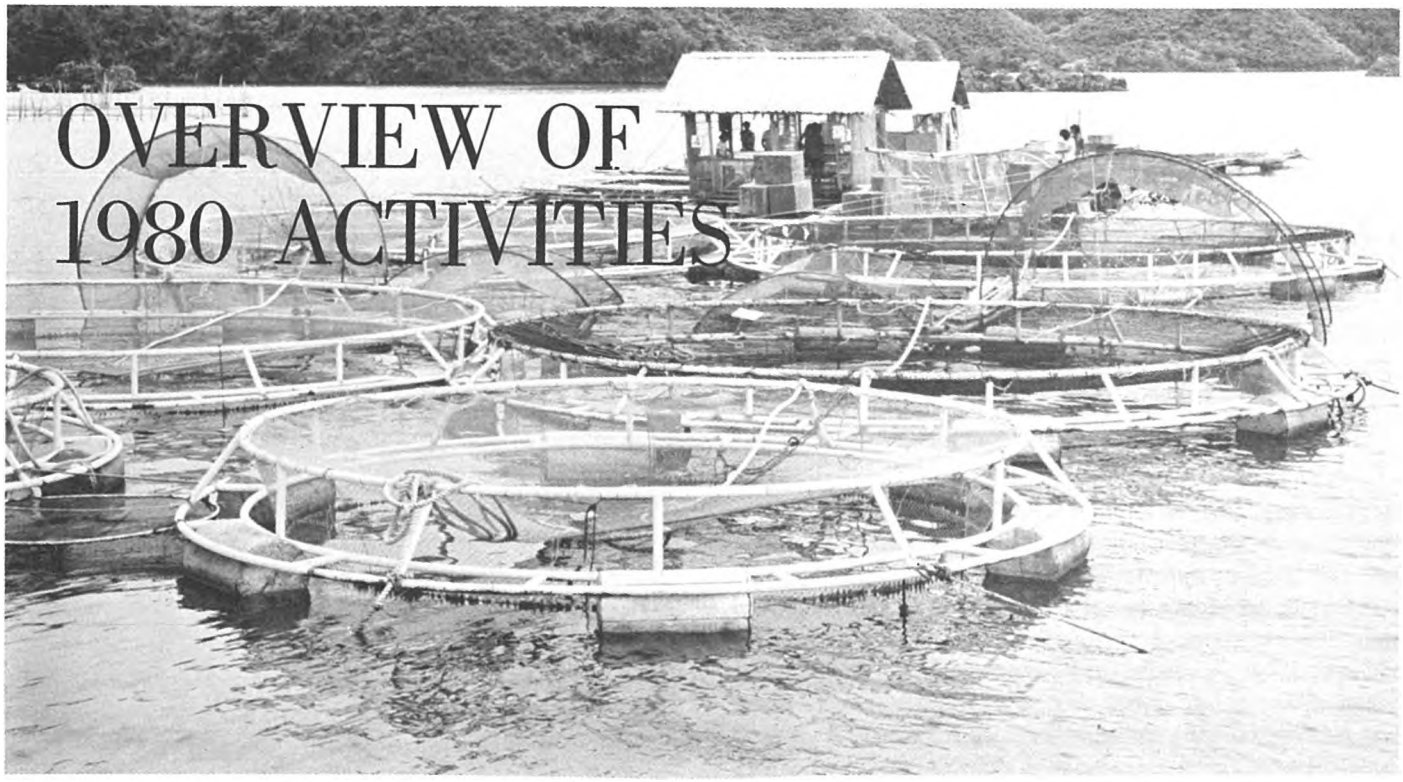
PERSONNEL MANAGEMENT DIVISION

Rodolfo Basilio, *Personnel Officer*
Enrique Soriano, Jr., *Personnel Officer & House Counsel*
Ma. Teresa Corpus, *OIC*

MEDICAL UNIT

Augusto Ravana, *Medical Officer*
Pancrasio Garay, *Medical Officer*
Hosanna Juario, *Medical Officer*
Edna Zapatos, *Medical Officer*
Yolanda Villarama, *Dentist*

OVERVIEW OF 1980 ACTIVITIES



Milkfish broodstock floating cages, 6 to 10 meters in diameter by 1.5 to 3 meters deep, at Igang Substation. Maturation and spontaneous spawning of 3½ to 5½ year-old cove-reared milkfish occurred in one of the 10-meter diameter by 3-meter deep floating cages.

During the year, the Department embarked on a new direction with the reorganization of its research activities focusing on: mariculture (Tigbauan Research Station), brackishwater culture (Leganes Research Station), and freshwater culture (Binangonan Research Station).

This new thrust has short- and long-term horizons although its formation was basically influenced by a 20-year scenario of the fisheries and aquaculture industries of the world, Asia in general, and Southeast Asia in particular. The emphasis on these priority areas for R and D will enhance the role of the Department in the region, and the Philippines in particular in solving the problems of the industry.

The most significant accomplishment was in milkfish research. Sexual maturation and spontaneous spawning in captivity of 3½ to 5½ year-old milkfish broodstock at Igang Substation first occurred between July and October 1980. The broodstock came from fry collected from the wild, raised at the Leganes experimental ponds and later stocked in floating cages at Igang Substation. This achievement, which could lead to the mass production of milkfish fry, prompted the Philippine Government to launch a National Bangus Breeding Program on December 27, 1980 for the refinement of the technique and to test its viability for commercial application. The Department also created a Technical Assistance Team for the said program.

Encouraging results have been produced by other ongoing and related studies on fish hatchery, crustacean hatchery, seafarming, nutrition and feed development, ecology, pathology and aquaculture engineering in Tigbauan; and milkfish nursery, tilapia culture, marine and freshwater prawn farming, and limnology in Binangonan. Focus of the studies were on prawn, milkfish, and mudcrab in Leganes Station; and on prawn broodstock and seafarming in Batan Substation.

One hundred twenty Department personnel participated in various local and foreign training programs, conferences, seminars, workshops, observation/study tours, and degree programs in line with staff development.

Regular training and extension programs were conducted on Aquaculture Research Methodology, Aquaculture Management for Prawns and Milkfish, and Small-Scale Prawn Hatchery Management. In addition, on-site training and off-campus practicum for students were also undertaken. These programs were attended by participants from the region and other parts of the world. Special courses on cage and pen culture techniques, milkfish culture, sponsored by IDRC; aquabusiness project development and management; and others, were also conducted.

Regular publications, technical reports, extension manuals and workshop proceedings were printed. Scientific papers authored by regular and visiting researchers were published in local and international journals. More than 30 research seminars were conducted by Department staff, visiting experts, and scientists.

The Department also established new linkages and strengthened existing relationships with various international and national agencies and organizations.

Tigbauan Research Station

The Station implemented eight research projects aimed at generating new or improved technologies based on problems faced in the aquaculture industry. The research projects are: fish hatchery, crustacean hatchery, seafarming, nutrition and feed development, ecology, natural food, pathology, and aquaculture engineering.

While most of the studies were conducted at the Tigbauan, Iloilo station, a few were done at various substations: Igang, Guimaras for milkfish broodstock; Himamaylan, Negros Occidental for seafarming; Batan, Aklan for prawn broodstock and seafarming; Tacloban, Leyte and Calape, Bohol for oyster farming; and Zamboanga City for outreach seafarming projects.

Four supportive units provided technical services: Centralized Analytical Laboratory for chemical analyses; Microtechnique Laboratory for preparation of slides for histological analyses; Research Information Services for storage and retrieval of research data, statistical analyses, and typing; Repair and Maintenance Unit for the installation, calibration, testing, and maintenance and repair of laboratory equipment.

The Tigbauan Research Station.

Fish Hatchery

Researches in the Fish Hatchery were conducted in an effort to a) increase the survival of wild milkfish fry, b) induce maturation of captive milkfish through hormonal and dietary manipulation, and c) develop techniques to induce spawning and to rear the larvae of milkfish.

FRY SURVIVAL STUDIES

1. Evaluation of milkfish fry catching gears. A survey was conducted on existing fry catching gears in Panay Island. The main gears utilized for collecting milkfish fry are classified into active or mobile filtering (bulldozer) and passive or stationary (taktak) filtering gear types. The active filtering types have two subtypes – the trawl and dragged seine. In terms of catch per unit effort, the bulldozer was the most efficient and taktak the least efficient fry catching gear. The active filtering type of gears can be utilized at any time, tide, or sea conditions. Milkfish fry mortality during collection is primarily due to mechanical injury.

2. Refinement of handling, holding, and transport techniques. A survey of milkfish fry storage and transport practices in Antique Province showed that the fry are commonly stored in plastic basins containing diluted seawater (16 to 24 parts per thousand salinity) at 5,000 to 6,000 fry per basin for 2 to 5 days. A study was conducted to determine the effect of three levels of temperature on the growth and survival of milkfish fry. Preliminary results indicated that the highest survival rate (98%) occurred among fry reared at 20° to 23°C for 38 days. This temperature level could be used to increase fry survival during storage and stunting.

A starvation study on newly-caught milkfish fry was conducted at 20 parts per thousand salinity. Results showed that after 5 days they became very transparent, emaciated and inactive. Mortality started 9 days after capture and reached median lethal time on the 12th to 13th day. Total mortality occurred from day 16 to 17. It is recommended therefore, that milkfish fry should be fed within the first 5 days after collection to prevent high mortality during storage.

BROODSTOCK DEVELOPMENT STUDIES

1. Broodstock development under different holding systems and dietary regimes. Sexual maturation in milkfish aging 3½ to 5½ years and weighing 2.1 to 4.1 kg, occurred in July to October, 1980. The fish were stocked as juveniles in 1975 to 1977 in an enclosed cove at Igang Substation, Guimaras Island, recovered in March, 1979, and transferred to 10 m diameter by 3 m deep floating cages. These were fed with commercial pellet (42% protein) twice daily at 1.5% of body weight per day. Out of 67 fish sampled from July to November, 1980, 26 were maturing, 30 were mature (11 fe-

males, 19 males), 3 were immature, 8 were spent. Mean weights of mature testes and ovaries were 38.3 g (11.0 to 107.0 g) and 127.1 g (57.0 to 308.0 g). Fecundity was 545,000 to 976,000 eggs. Spontaneous spawning occurred on 3 August and 7 August, 1980, with over 500 and 900 eggs collected, respectively. Fertilization rate was 55 to 65%; hatching rate was 30 to 50%; and larval survival was 50%.

Spent wild spawners (sabalo) caught between 1977 and 1979, and similarly kept in floating cages and sampled in June and August, 1980 had regressed gonads. The results indicated that wild spent sabalo require different conditions for maturation from cove-reared stock. Spent sabalos held in concrete tanks and fed with trash fish at a daily rate of 3% body weight had gonads in early stages of maturation in April, 1980.

Milkfish (3½ to 5½ years old) held in 3 m diameter cylindrical rotating cages and fed with diets with 40% protein from various sources had immature gonads when sampled in August, 1980. Fish fed with dried alamang (*Acetes* sp.), however, had slightly higher gonadosomatic index (GSI) and higher percentage weight gain than those fed with fish meal or a combination of fish meal and dried alamang.

2. Hormonal induction of gonad development in milkfish. Immature cove-reared fish and spent sabalos did not respond to hormones administered by implantation, injection or intraperitoneal infusion. A slight rise in GSI was noted in March in the hormone-treated groups. Gonad development was up to early maturation stages (early yolk vesicle and spermatocyte stages). A maturing milkfish was sampled from a cage where hormonal treatment had been terminated two months earlier.

Sampling in November and December from a cage where all experimental fish (hormone-treated, sham implanted and untreated fish) were transferred after termination of the experiment yielded maturing (5 females, 6 males) and mature (4 males) fish.

Radio immunoassay of gonadotropin (GTH) from sera of milkfish injected or implanted with salmon pituitary showed similar GTH profiles. Serum GTH in both groups increased one day after administration but returned to basal level one week after administration. The expected sustained GTH release by the hormone implants was not obtained from the hormone-cholesterol pellet preparation. Low responsiveness to the hormones was likely due to the unsuitable method of hormone administration and handling stress.

SEED PRODUCTION

1. Induced spawning of milkfish/mullet. Nine female sabalos from both wild and captive stock were induced to ovulate/spawn in captivity. Hormonal injections were given intramuscularly a few centimeters below the dorsal fin. Results indicated that a priming dose followed after 12 to 24 hours by a second injection was effective in inducing milkfish with an average egg diameter equal to or greater than 0.65 mm to ovulate in captivity. The priming dose used was 10 milligrams (mg) salmon pituitary homogenate (SPH)/kg body weight of fish + 1,000 International Units (IU) of Human Chorionic Gonadotropin (HCG)/kg body weight and the second injection consisted of 10 mg SPH/kg body weight + 2,000 IU HCG/kg body weight. About 10 hours after the second injection the fish started releasing eggs. Fish with ave-

Sorting and counting of milkfish eggs collected from spawnings of mature milkfish stocked in floating cages of Igang Substation.

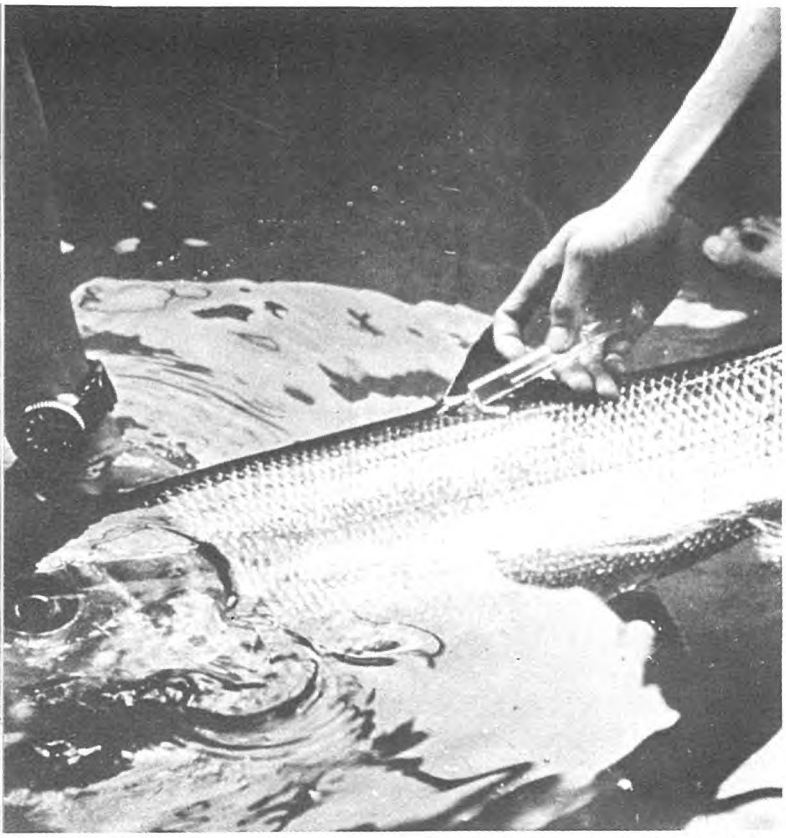
rage egg diameter lower than 0.65 mm did not respond well to the hormone injection.

A total of 23 maturing and mature female mullets, *Mugil cephalus* and *Valamugil seheli,* collected from the wild, were also induced to spawn in captivity. Female mullets with an average egg diameter equal to or greater than 0.60 mm were successfully induced to ovulate in captivity by following the "spawning injection" developed for milkfish and following the method developed by C.M. Kuo *et al.* in 1979. Females with average egg diameter lower than 0.60 mm did not respond well to the "spawning injection." Those injected with estradiol-17-beta (E2) in addition to HCG and SPH initially showed increasing egg diameter. However, the effect of E2 could not be assessed because the experimental fish died before ovulation could take place.

2. The effect of exogenous hormone injection on milt consistency in newly-caught sabalo. The effects of single injection of the long-acting androgen preparation, Durandron Forte "250", and of HCG on milt consistency in newly-caught sabalo were studied. Results indicated that a day after the hormone injections, their milt became more fluid and copious and dispersed easily when mixed with seawater. Fish injected with Durandron Forte "250" were maintained in good running condition for a maximum of 7 days while those injected with 5,000 IU HCG were maintained in good running condition only up to 3 days. No milt could be extracted from the control after being held in captivity for 2 to 3 days.

3. Larval rearing of milkfish. Milkfish larvae were reared up to the fry stage by feeding with the rotifer *(Brachionus plicatilis)* alone from day 3 to day 10 and rotifer, brine shrimp *(Artemia salina)* nauplii and copepods from day 11 to day 21. The feeding schedule for rearing milkfish larvae is shown in Fig. 1. Survival rates in 600-liter experimental tanks ranged from 13% to 74% with an average of 44%. Results also indicated that survival rate was higher in tanks containing both the green algae *Chlorella virginica* and *Tetraselmis chuii* compared to *Chlorella* alone.

4. Cryogenic preservation of milkfish and other fish sperm. The use of various extenders: potassium chloride, sodium chloride, glucose, sodium-citrate, Ringer's solution, cow serum and milkfish serum to preserve milkfish sperm was tested at 0° to 4°C and at −196°C using liquid nitrogen. Results showed that milkfish serum was the best extender in both studies. After 5 days of preservation at 0° to 4°C using milkfish serum, good motility (≥30%) and fertilization rate of 6.7 to 18.6% were observed. Using other extenders, sperm were no longer motile after two days. Fertilization rates of 4 to 5 days cryopreserved sperm had an average of 67.5% with milkfish serum, 60.5% with 0.40 M glucose, 58.0% with 0.10 M sodium chloride, 41.2% with Ringer's solution and 31.9% with cow serum. This is the first report on the successful preservation of milkfish sperm and the the use of milkfish serum as extender. The same extenders were tested on *Mugil cephalus, Valamugil seheli* and catfish, *Clarias batrachus.* Mullet serum was the best extender for *M. cephalus* sperm; motility was extended up to 16 days. For other extenders, motility was sustained up to a maximum of only 9 days. For *V. seheli,* milkfish serum was the best; motility was extended up to 17 days. Motility in NaCl and Ringer's solution was extended up to only 7 days.



Hormones are injected intramuscularly to anaesthetized sabalo.

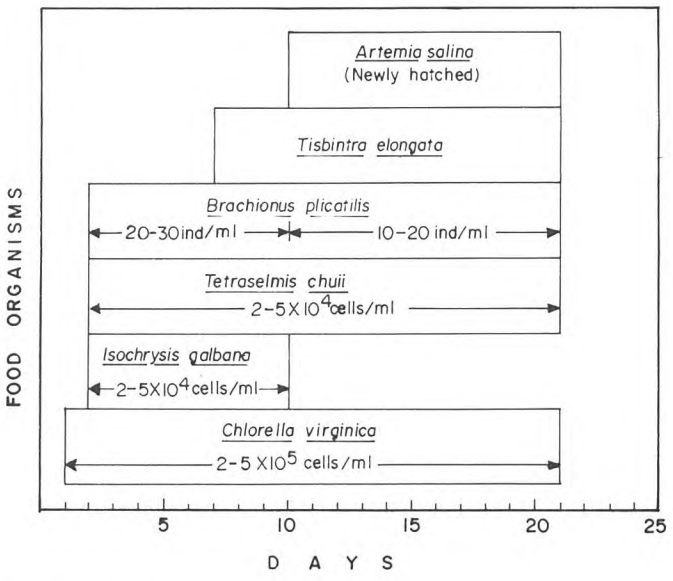
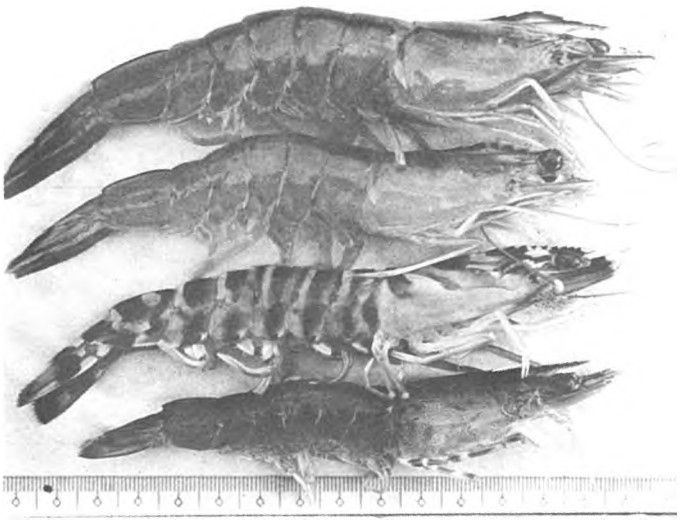


Fig. 1. Feeding schedule for milkfish larvae during 21-day rearing period.

Crustacean Hatchery

Research in this project involved three penaeid prawn species namely, *Penaeus monodon, P. indicus* and *P. merguiensis* with emphasis on *P. monodon.* Studies were oriented towards two objectives: refinement of prawn broodstock technology, and refinement of prawn small-scale and large-tank hatchery technology. In addition, the big-tank hatcheries supplied the experimental needs of the Leganes ponds and other units.



Aside from sugpo, *Penaeus monodon,* potentially important penaeid species include (from top) *P. merguiensis, P. indicus, P. japonicus,* and *Metapenaeus ensis.*

BROODSTOCK DEVELOPMENT

1. Different pellets for prawn broodstock. A study was conducted to evaluate the effect of three different pellets (SEAFDEC-formulated, Ralston Purina and Vitarich Crustacean Pellet with 44%, 24% and 37% crude protein, respectively) on the maturation and survival of *P. monodon* broodstock. Preliminary results showed higher survival, fecundity and hatching rates of animals fed with the SEAFDEC-formulated broodstock pellet. The Vitarich pellet was consistently inferior to the first two.

2. Substrate types. In a study comparing two types of substrates for prawn broodstock tanks, ablated females in the tank with white coralline substrate gave significantly higher average hatching rates, and total nauplii production, than those in the tank with the black gravel substrate. No differences were observed in the fecundity, spawning and survival rates in both treatments.

An important observation was that nightly sampling produced more spawnings (48) and nauplii (6.8 million) compared to sampling done twice weekly (29 spawnings and 3.0 million nauplii).

3. Flowthrough vs. recirculating water systems. The standard 12 cu m prawn broodstock tank in the Tigbauan Station operates on a flowthrough water system which has a great volume requirement. To provide an alternative to the flowthrough system, a study was conducted comparing maturation and survival of *P. monodon* broodstock in recirculating and flowthrough tanks. In general, the flowthrough system produced higher mean fecundity and mean hatching rate compared to the recirculating system. Survival rate of broodstock was also higher for the flowthrough tank but did not differ significantly from that of the recirculating system. In general, female survival was lower compared to that of males because of additional stress due to ablation, sampling and spawning in both treatments.

4. Different ablation methods. Eyestalk ablation, which induces ovarian maturation in *P. monodon* and other penaeids, can be performed in a number of ways other than the standard pinching procedure adopted since 1976. Preliminary results from a study of various ablation methods showed that cautery (using silver nitrate bars) and simple cutting produced more eggs and larvae, and better hatching rates in comparison to pinching and ligation (tying with a nylon thread).

5. Larval production by broodstock. In 1975-76, 100% of nauplii needs were supplied by wild spawners (Fig. 2). In 1980, with improved broodstock techniques, about 80% of the *P. monodon* and *P. indicus* larvae stocked in the small and large-tank hatcheries were produced by captive females (ablated for *P. monodon)* kept in the Tigbauan maturation tanks. Approximately 10% came from broodstock matured in the Batan offshore pens and another 10% from wild spawners.

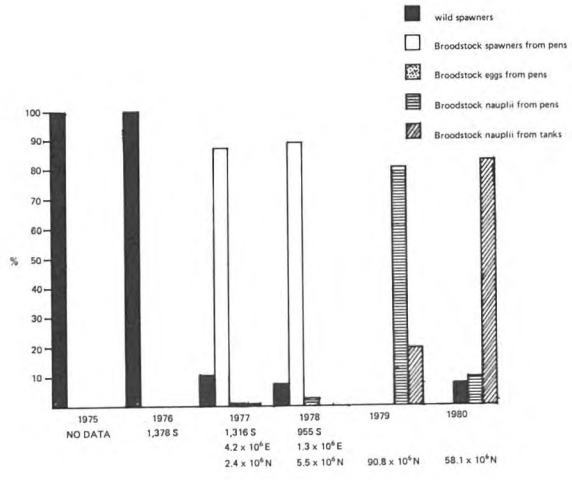


Fig. 2. Sources of spawners, eggs or larvae of *Penaeus monodon* and *P. indicus* stocked in the big tank prawn hatchery of SEAFDEC AQD in Tigbauan, Iloilo (based on total nauplii stocked for 1977-1980).

Putian, *Penaeus indicus,* has become an increasingly important aquaculture species. In 1980, a total of 14.7 million nauplii was produced in broodstock tanks. The first batch of wild females, matured and spawned in March 1979, already produced the fifth generation with regular stocking of hatchery-reared fry in the Leganes ponds, and retrieval of two-to three-month old adults for maturation and larval rearing in Tigbauan.

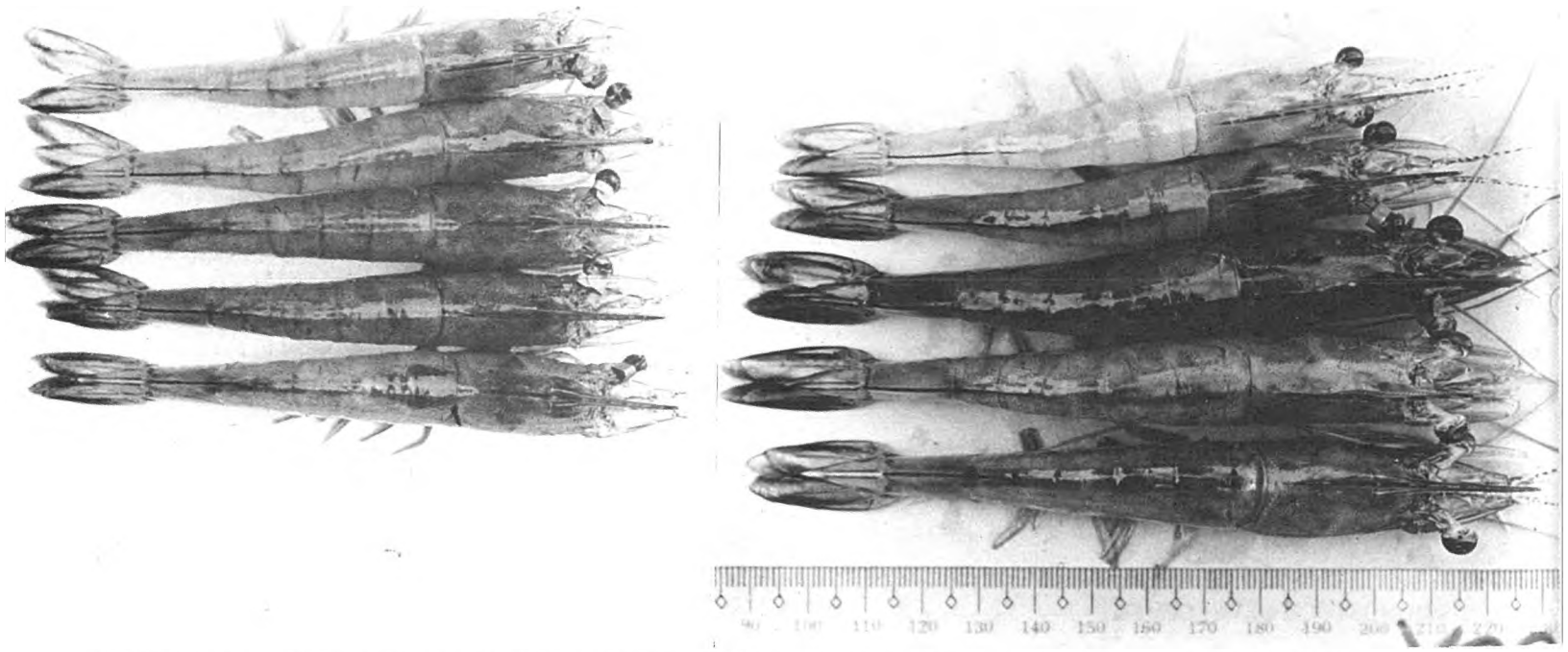
SMALL-TANK HATCHERY

1. Feeding studies. A study on the effect of feeding *Chaetoceros calcitrans* and *Tetraselmis chuii* on growth and survival of *P. monodon* larvae showed that *C. calcitrans* is a better food for the early zoeal stages due to its smaller cell size (4-5 microns) compared to *T. chuii* (12-15 microns). At the mysis stage, both algal species were observed to provide comparable growth. In terms of macronutrient composition, percent crude protein and carbohydrates were significantly higher in larvae fed with *T. chuii;* lipid content was higher in larvae given *C. calcitrans.*

In another experiment to determine growth and survival of *P. monodon* nauplii (N_6) given different diatoms, highest mean survival rate at mysis (M_1) was obtained for those fed with *Chaetoceros gracilis,* followed by mixed diatoms, *C. calcitrans,* and *Skeletonema costatum* (Fig. 3). The *C. gracilis* and *C. calcitrans* populations in the larval tanks were also observed to be more stable, with few accumulated sediments. Cell size and species diversity of food seemed to be the most influential factors affecting the growth and survival of the larvae.

The survival rate of *P. monodon* nauplii reared to myses was compared using live vs. sun-dried *C. gracilis* and *S. costatum.* Survival was significantly higher when larvae were fed with either sun-dried or live *C. gracilis* (85 to 87%), compared to live or sun-dried *S. costatum* (51 to 53%) (Fig. 4).

Standard hatchery procedure is to feed the prawn larvae morning and afternoon, maintaining algal counts at a constant level. Using either *C. calcitrans* or *C. gracilis,* a study was conducted to compare the standard feeding scheme (5×10^4 cells/ml at both A.M. and P.M. feedings) with another where feeding level is doubled in the afternoon. Preliminary results showed highest survival of postlarvae with *C. calcitrans* at doubled P.M. feeding level (74.6%) followed by *C. gracilis* using the standard feeding scheme (60.3%).



Different stages of maturity of putian, *Penaeus indicus.* Unlike sugpo, putian females mature in captivity with (1) or without (2) ablation.

2. Use of Treflan R, Treflan EC and Trifuralin as therapeutic agents in controlling fungal infection in *P. monodon* larvae. The use of Treflan R had no beneficial effect on fry survival at almost all concentrations tested whereas higher fry survival was obtained at 0.006 parts per million Treflan EC and 0.1 parts per million Trifuralin. Reddening occurred anywhere along the entire body length of the larvae and was observed in all test concentrations throughout the experiment.

3. Effect of temperature and salinity combinations on egg and larval development. *P. monodon* eggs were incubated and larvae reared at various combinations of temperature (23°C, 28°C, 33°C) and salinity (23, 28 and 33 parts per thousand). Salinity showed a highly significant effect on hatching rate and survival rate from nauplii to first zoeal stage, whereas temperature did not. The highest hatching and survival

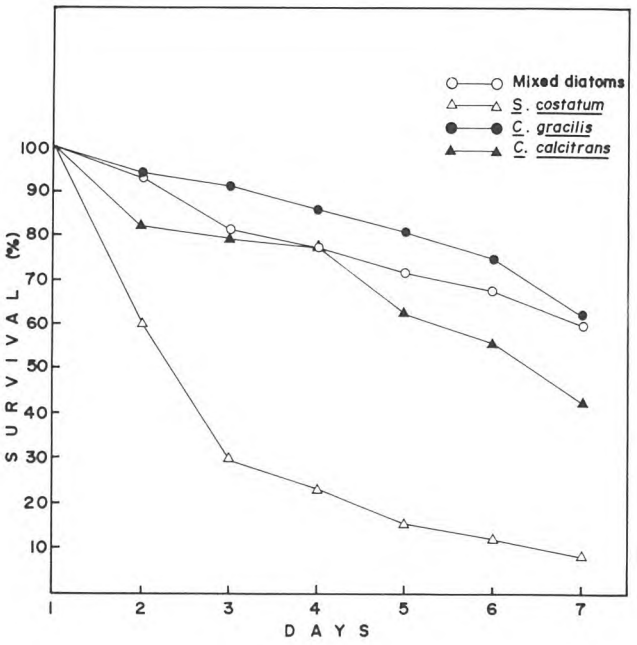


Fig. 3. Mean daily survival of *Penaeus monodon* larvae (N_6 to M_1) fed with different types of diatoms.

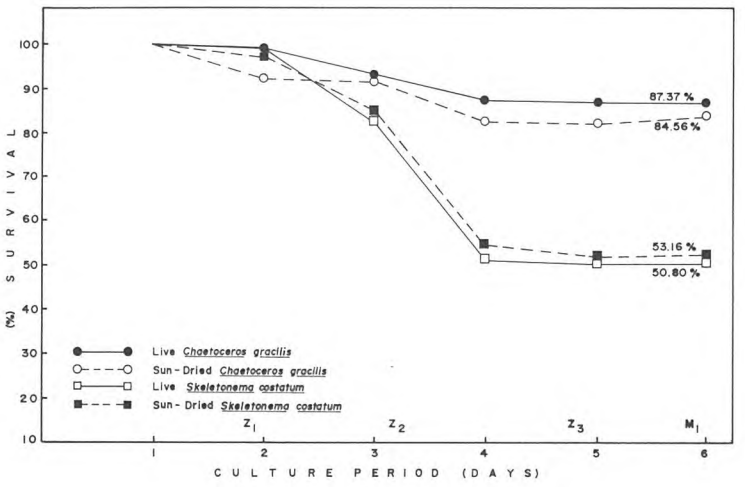
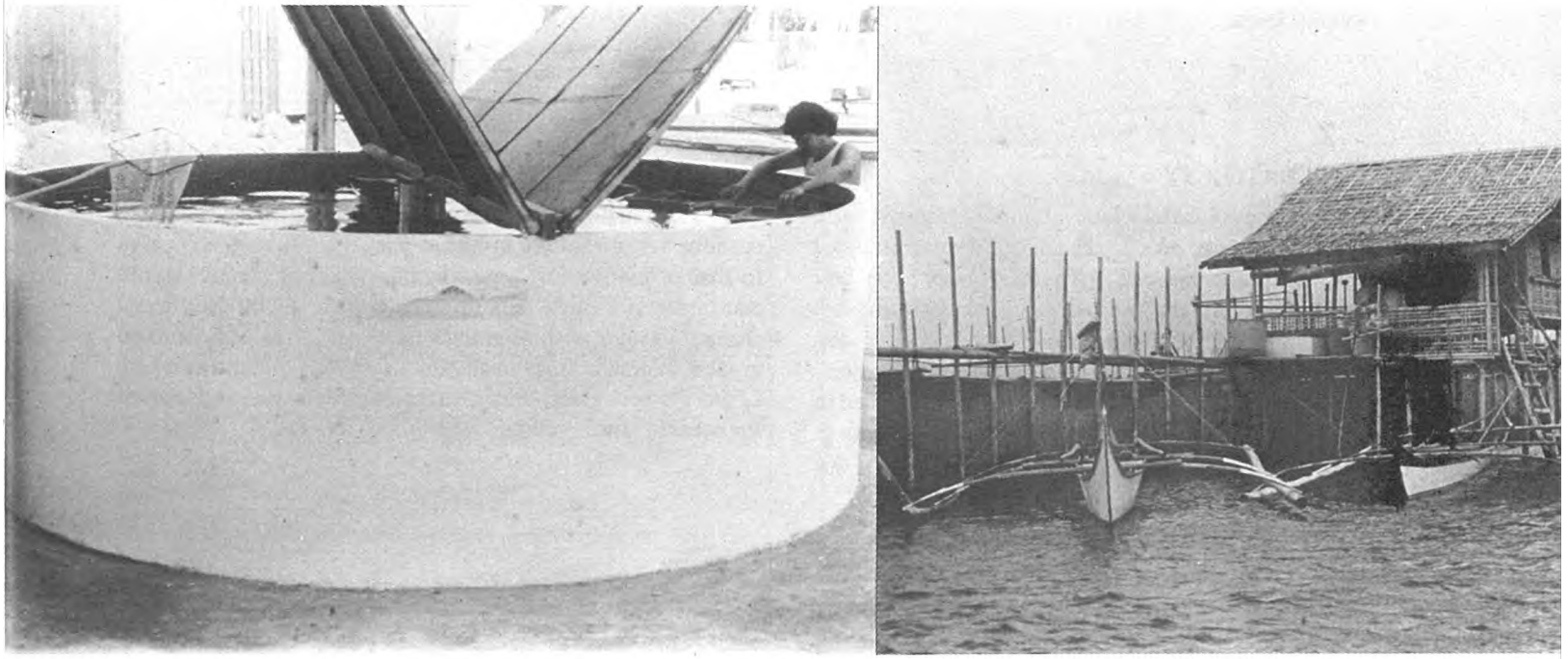


Fig. 4. Survival rate of *Penaeus monodon* larvae from N_3N_4 to M_1 using different algal species.

rates were obtained at a salinity of 33 parts per thousand at all temperature levels (Fig. 5). However, high temperature significantly hastened hatching time and molting from nauplius to zoea. Eggs and nauplii survived sudden changes of temperature and salinity, in contrast to zoeae and myses. Developing eggs and nauplii subsist on stored yolk, whereas the latter stages depend on external food sources and when stressed, feeding activity is reduced or stopped.

4. Optimum stocking density of postlarvae in nursery tanks. Optimum stocking density of P_5 *P. monodon* grown to juvenile stage in 1.4 ton nursery tanks was 5,000 to 10,000 P_5/nursery tank with survival rates ranging from 87.4 to 92.1%. At 20,000 to 40,000/tank, survival rates ranged from 41.8 to 45.6%. Cannibalism was pronounced as the density went beyond 10,000/tank due to overcrowding.

It is recommended to extend the hatchery period to include the nursery phase to grow the postlarvae to juveniles (P_{35}). Farmers will find it more advantageous to stock the relatively sturdier P_{35} in rearing ponds.



Since 1977, over 90% of the larval needs of the prawn hatcheries has been supplied by broodstock *P. monodon* and *P. indicus* matured in ferrocement tanks (left) or offshore marine pens.

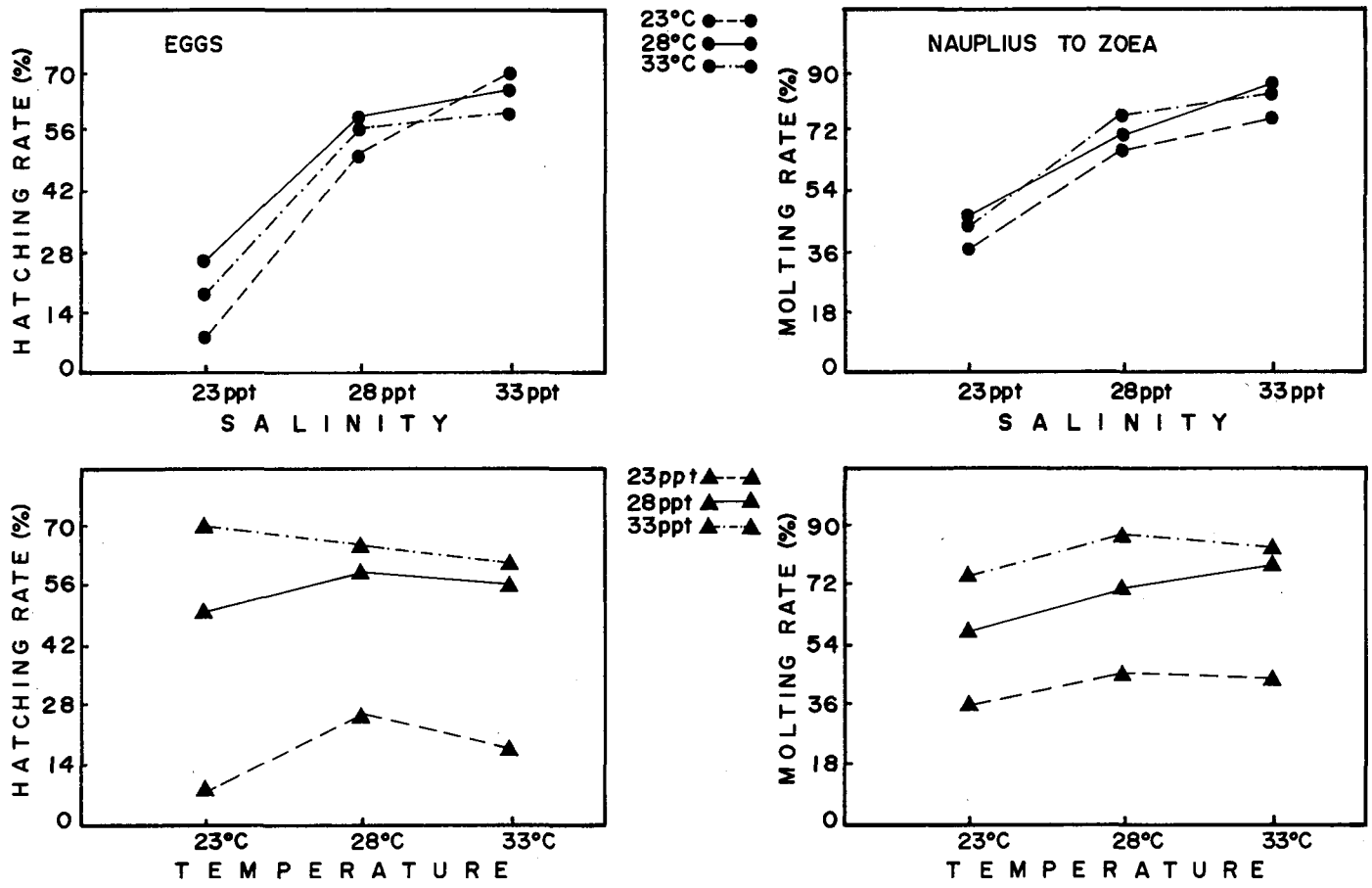


Fig. 5. Percent hatching of *Penaeus monodon* eggs and percent molting from nauplius to zoea at different temperature and salinity levels.

LARGE-TANK HATCHERY

A total of approximately four million *P. monodon* and *P. indicus* postlarvae was produced in 1980. Average survival from nauplii to postlarvae was 5.9% for *P. monodon and* 20.5% for *P. indicus,* a slight improvement over 1979 survival rates of 5.3% and 15.5% for *P. monodon* and *P. indicus,* respectively. Survival was better during the dry months compared to the wet months. Majority of the fry were stocked in Leganes ponds, the rest were used in other experiments (e.g. thesis studies) or sold to the private sector.

Transferring the larvae at the mysis stage from indoor to outdoor tanks resulted in higher postlarval survival compared to that of the previous year when the standard practice was to rear larvae in a single tank up to harvest stage with daily water change. Feeding with *C. gracilis* on a mass scale was also tried in view of results from small-tank hatchery experiments where *C. gracilis* performed much better than *Skeletonema costatum* for penaeid larval rearing.

Seafarming

The main thrust of the Seafarming Project was the development of technology for growing and harvesting molluscs and finfish low in the food chain. Research effort was initially geared towards the development of technology for forecasting spatfall of mussels and oysters for the benefit of farmers. Techniques for optimum spat collection were studied. Preliminary trials on the feasibility of cultivating commercially important finfish in netpens in coastal waters were also started.

MOLLUSCS

Daily sampling of planktonic mussel and oyster larvae has been conducted in Himamaylan since March, 1979. The most significant finding was that the highest larval counts for two consecutive years occurred at about the same time of the year: March 19, 1979 with 1,381 larvae/cu m and March 4, 1980 with 224 larvae/cu m. This suggests an annual periodicity in the spawning peaks.

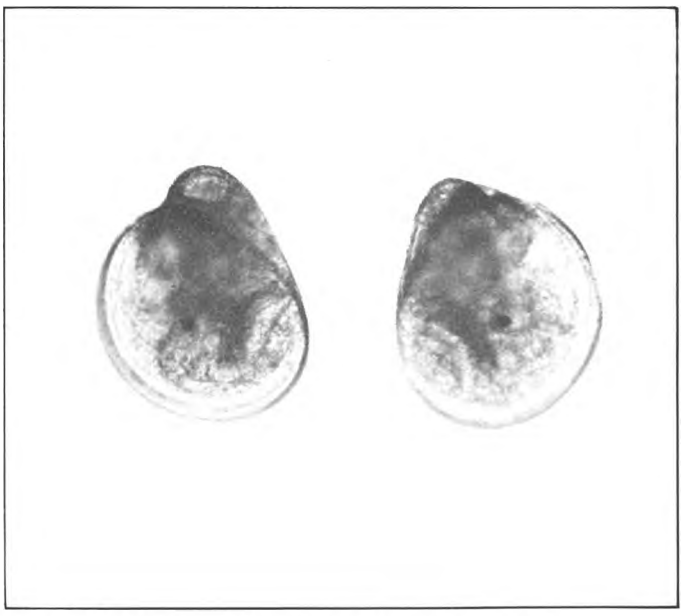
1. Hatchery production of slipper oyster spats. Preliminary studies on the feasibility of a mollusc hatchery were undertaken. The slipper-oyster, *Crassostrea iredalei,* was successfully reared through its larval stages. Fertilized eggs of *C. iredalei* measured 47 to 50 micrometers (μm) in diameter, and developed into the trochophore stage 12 to 15 hours after fertilization, at 26.5 to 30°C and 30 to 32 parts per thousand salinity. Straight-hinge veligers developed into eyed pediveligers after 18 to 22 days and settled on shells of the windowpane oyster. Given this information, spatfall of oysters can be predicted two weeks in advance.

2. Culture of green mussels. Mussels were cultured in Himamaylan, Negros Occidental using the hanging method. A total production of 7.98 metric tons was obtained from three rafts having an aggregate surface area of 124 sq m. This represented an average of 2.66 tons per raft.

The long-line method of culturing mussels was tested in 10-meter deep waters in Batan, Aklan using different types of floats and buoys. A low-cost buoy was developed, basically consisting of a cement-coated styrofoam block weighing 38 kg. Buoyancy was 134 kg. Studies are presently being conducted to improve the performance of these low-cost buoys.

3. Post-harvest handling of green mussels. Green mussels harvested from rafts were declustered by hand, washed, and packed in three ways: a) in sacks only (traditional method), b) in sacks inside a styrofoam box, and c) in sacks inside a styrofoam box containing a two-kg block of ice.

Zero hour was set as the time of packing at the farm site. From the farm site, the packed mussels were then transported to Tigbauan, Iloilo, the trip lasting 5 to 6 hours. Survival was monitored every 12 hours by counting the dead mussels and removing them afterwards.



Eye-spotted larvae of the oyster, *Crassostrea iredalei.*

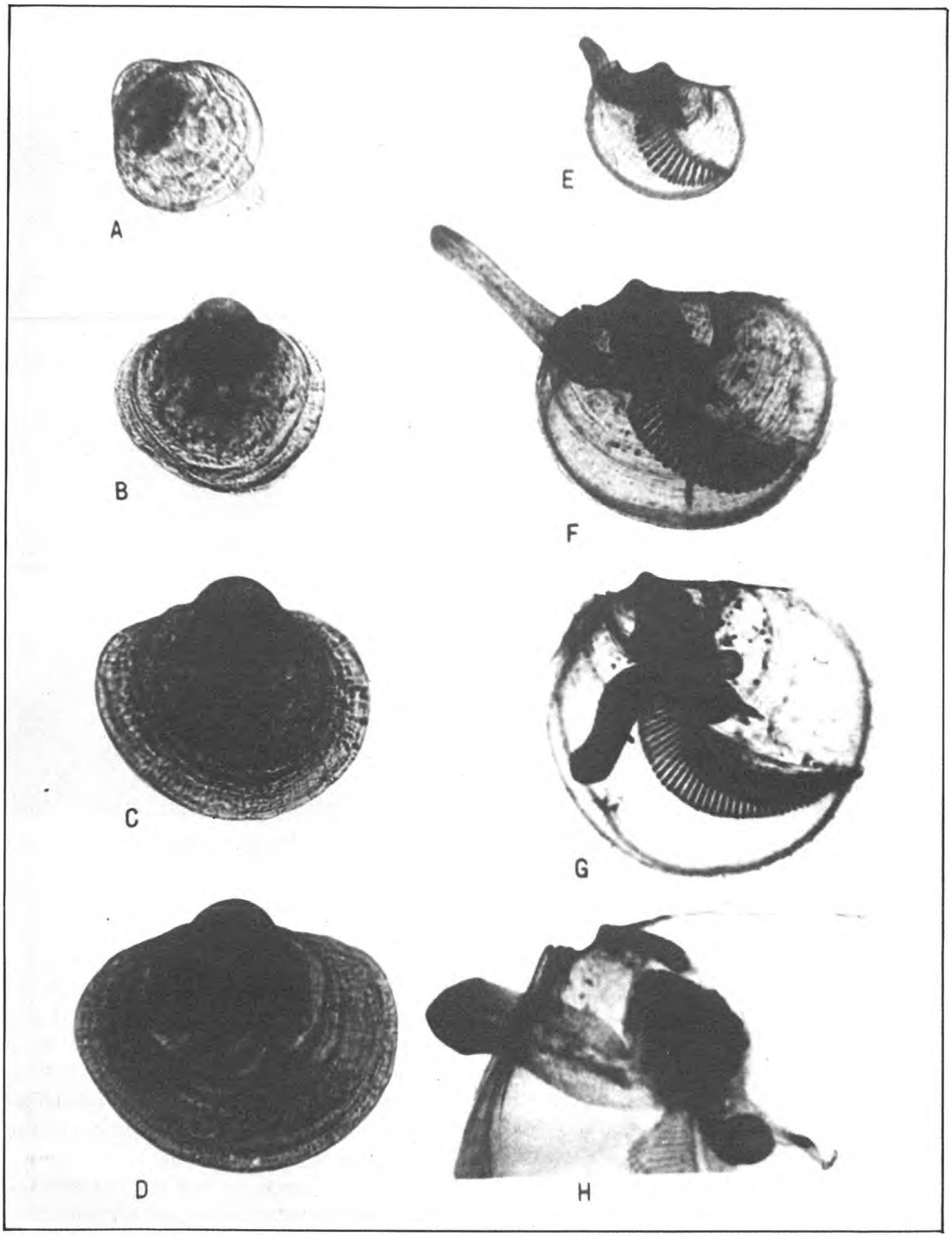
2-day old oyster, *Crassostrea iredalei* **spat.**

Green mussels, *Perna viridis.*

Half of the mussels which were not chilled were dead after 36 hours, while chilled mussels survived for three days without any mortality. However, high mortality of chilled mussels occurred after 6 days. The temperature inside the iced styrofoam box ranged from 6 to 9°C.

4. Completion of the life cycle of the windowpane shell. Mature windowpane oysters, *Placuna placenta,* were induced to spawn in the laboratory using water manipulation. Shelled larvae grew well on *Isochrysis galbana.* At 27°C and 28 to 29 parts per thousand salinity, the larval period lasted only eight days. Larvae metamorphosed at lengths ranging from

Himamaylan mussel farm.



Selected life stages of *Placuna placenta*. A – 0.18 mm larva, B – 0.23 mm postlarva, C – 0.30 mm postlarva, D – 0.36 mm postlarva, E – 1 mm juvenile, F – 2 mm juvenile, G – 3 mm juvenile, H – 5 mm young adult.

220 to 230 μm. Metamorphosed larvae and postlarvae possessed a well-developed and prominent foot and were capable of byssal attachment. Juveniles 2 to 10 mm in diameter plunged into the mud by repeated sharp contractions of the adductor muscle. It is then possible that this bivalve lives not on the surface of the mud, as is generally described, but under a mud-camouflage, usually bearing a layer of mud and silt on its upper shell. In nature, the presence of *Placuna* is detectable only by the semi-circular band of shallow excavations at the edge of the shell. These research results will be the basis of future management programs for the *Placuna* fishery of the Philippines.

FINFISH

Preliminary observations were made on the pen culture of the spadefish, *Scatophagus argus* in mussel farming sites in Himamaylan, Negros Occidental. Growth of *S. argus* from post-metamorphosis to fingerling stage was sustained solely by plankton present in the water. Heavy net fouling and the entry of predators caused high mortality.

A method of acclimating the Nile tilapia *(Tilapia nilotica)* from freshwater to seawater (32 parts per thousand) was developed. The whole acclimation period took 5 to 7 days. The next phase of the study is the experimental culture of acclimated fish in marine pens.

Nutrition and Feed Development

Mixing of feed ingredients in a Hobart mixer is one of the steps in the preparation of artificial diets for prawn and milkfish.

Research efforts on nutrition and feed development focused on the development of practical diets suitable for milkfish and prawns at their various life stages. To meet the objectives of the section, a three-pronged approach was adopted by studying: 1) the nutritive value of feedstuffs, 2) nutritional requirements of both species, and 3) digestive physiology of milkfish.

PRAWN

The value of some feedstuffs such as ipil-ipil leaves, as a partial substitute for fish meal, an expensive feed ingredient, was studied. Chicken egg prepared in various forms, and other formulated diets were evaluated to determine their effectiveness in promoting growth and survival.

Whole eggs cooked in boiling water with constant stirring or whole egg powder bound with carboxy methyl cellulose, cornstarch, cassava starch or agar, were fed to *Penaeus monodon* (zoea) larvae in aquaria containing 5 liters of filtered seawater. In all treatments, zoeal development was delayed and no larvae reached the mysis stage.

Ipil-ipil, *Leucaena leucocephala,* is a good and cheap source of protein. However, mimosine, a toxic substance present in the leaves, can cause poor growth and survival. Unsoaked (commercially obtained) and soaked (locally obtained) leaves were fed to prawn juveniles in a diet computed to give 5 or 10 g protein of the total 30 g protein in the diet. Soaking the leaves in fresh water removes mimosine.

Prawns thrived best in the diets containing lower amounts of ipil-ipil leaves, regardless of whether the leaves were soaked or not. Mean weight gains of the prawns given the higher ipil-ipil content were significantly lower than those given the lower amounts of ipil-ipil. Ipil-ipil protein up to 16% of the total protein in the diet was not detrimental to growth and survival of juvenile prawns.

In the search for low-cost protein sources, the interrelationship between animal and vegetable protein was studied. Prawn juveniles were fed with diets containing animal: plant protein ratios of 0:1, 1:4, 1:3, 1:2, 1:1 and 2:1 at a rate of 10% body weight per day for 10 weeks. The diets were estimated to have the same energy (2,870 kcal) and nitrogen (28% protein) content. The animal protein mix consisted of 50% Peruvian fish meal and 50% shrimp head meal. On the other hand, the plant protein mix was composed of 60% soybean meal, 25% ipil-ipil leaf meal and 15% corn gluten meal.

Results showed that the prawns fed with the plant protein diet had the highest weight gain which was significantly higher than in prawns fed higher levels of animal protein (Fig. 6). Slightly lower weight gains were obtained by prawns fed with diets containing 1/4 and 1/5 of animal protein. Significantly better percentage feed efficiency values were obtained for the animal: plant protein ratios of 0:1, 1:4, and 1:3 which were 5.8, 5.2, and 4.9, respectively.

In studies to determine the qualitative carbohydrate requirement of *P. monodon* juveniles, animals were reared on semi-purified diets containing 10% or 40% dextrin, sucrose, maltose, molasses, cornstarch, sago palm starch or cassava starch for 6 weeks. Prawns fed with diets containing maltose and molasses died within 10 days of rearing regardless of the level in the diet. The 10% sucrose diet gave the highest survival while among the starches, sago palm provided better survival. Presently, sago palm starch is used as a binder for prawn diets.

MILKFISH

Milkfish fingerlings were reared in fiberglass aquaria with flowthrough seawater and fed with various formulated diets and lablab*. The treatments were: I-formulated diet with ipil-ipil, II-formulated diet with soybean, III-lablab, IV-formulated diet with ipil-ipil + lablab, V-formulated diet with soybean + lablab. Treatment II gave significantly higher growth rate (134.32%) compared to other treatments (Table 1). Survival rate was poor for all treatments and feed conversion was relatively low. However, the feed conversion value in the diet with soybean (Treatment II) was the best. Although the lablab is the food of milkfish reared in ponds, it did not provide good growth and survival when fed to milkfish reared under laboratory conditions. Factors such as freshness of lablab and lack of sunlight in the laboratory could have affected its nutritive value.

*Microbenthic complex of diatoms, blue-green algae and invertebrates.

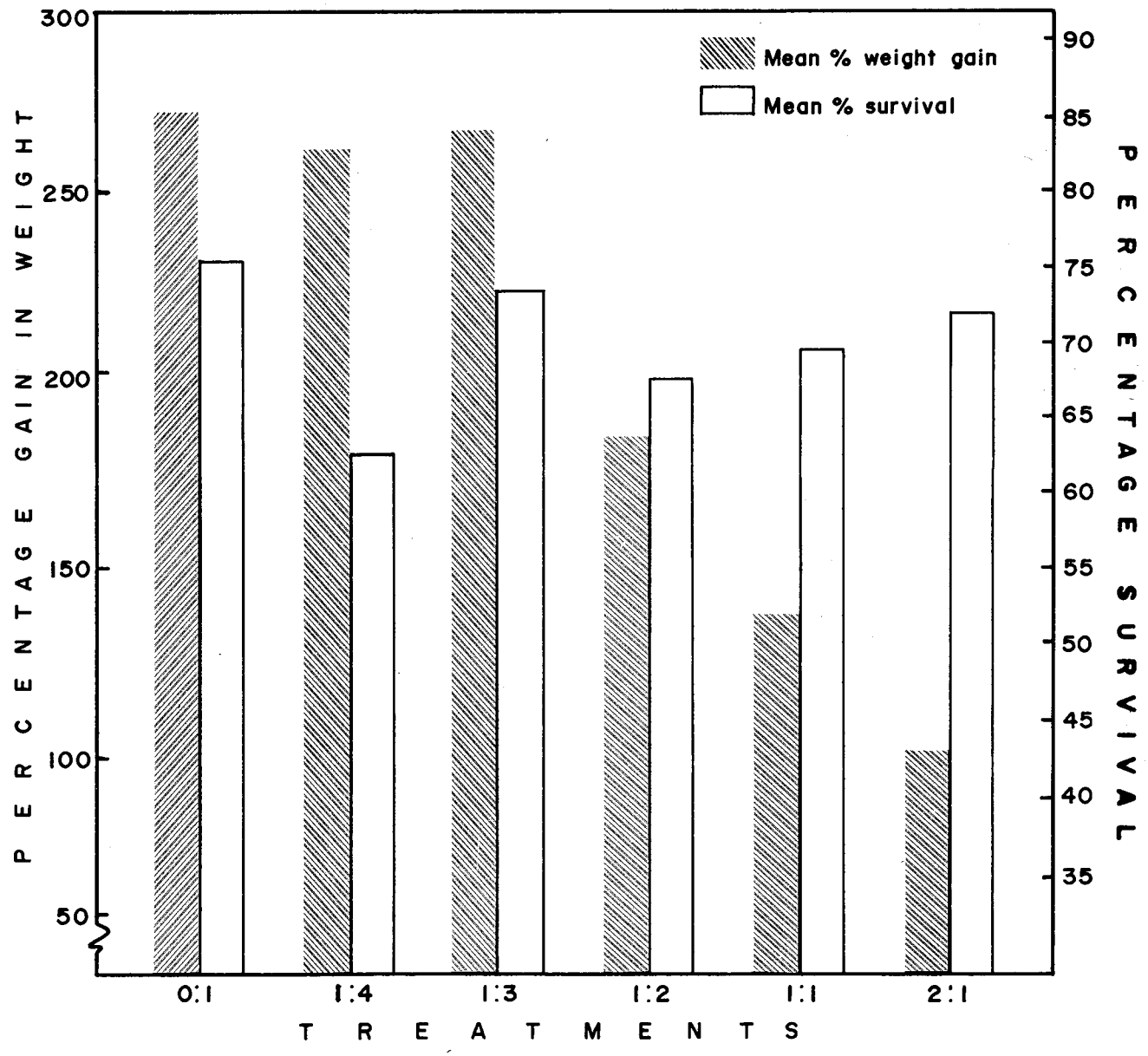


Fig. 6. Mean percent gain in weight and percent survival of *Penaeus monodon* juveniles fed diets containing various ratios of animal-plant protein.

Table 1. Mean growth rate, feed conversion, and survival rate of milkfish fingerlings fed different diets[1/]

Treatment	Average weight (g)		Growth rate	Survival rate	Feed conversion
	Initial	Final	(%)	(%)	
I	.37	.62	66.53[b]	37.77[a]	14.72[a]
II	.41	.97	134.42[a]	33.33[a]	7.86[a]
III	.36	.42	18.49[c]	25.00[a]	301.435[b]
IV	.39	.48	20.87[c]	34.44[a]	107.69[a]
V	.41	.60	47.78[b]	41.11[a]	40.98[a]

[1/] Treatment means with the same superscript are not significantly different at $P>0.05$.

In another experiment, milkfish fingerlings thrived poorly on diets that contained both low and high levels of ipil-ipil leaves. Under the conditions of the experiment, ipil-ipil leaves may not be a good substitute for fish meal in milkfish fingerling diets.

The effect of various sources of lipids: cod liver oil, corn oil, shark oil, coconut oil, soybean oil and beef tallow oil on growth, survival and body composition of milkfish fingerlings was determined. Preliminary results showed that milkfish fingerlings attained better growth when fed with coconut and soybean oil diets. However, survival was better in fish fed with the diet containing beef tallow oil.

The International Foundation for Science has funded a study to determine the energy-protein requirement of *Chanos chanos* fingerlings. A series of experiments has been conducted, two of which were done in 1979 and four in 1980.

Protein, carbohydrate, and fat levels were varied in each of the experiments from 10 to 55% protein, 15 to 55% carbohydrates, and 5 to 10% fat. Milkfish fingerlings were fed semi-purified diets for a period of 8 to 10 weeks. Results indicated a protein requirement ranging from 35 to 50% depending on the size of the fish, carbohydrate from 20 to 25% and fat, 10%. Caloric value of 350 to 370 kcal/100 g diet or 78 kcal/g protein is tentatively recommended.

One of the problems of the milkfish industry is the seasonality of milkfish fry. Although concessionaires are able to hold the milkfish fry from the peak season to the scarce period, methods for holding them with low mortality have yet to be developed. For this reason, the project has formulated a practical diet for holding and stunting and evaluated it in terms of feeding level, stocking density, feeding rate, and feeding frequency.

Wild milkfish fry were stocked in fiberglass aquaria with seawater at a density of 15 ind/liter. The fish were fed twice daily at 10, 20, 30, 40, and 50% of body weight per day. Mortalities were first observed after about 5 days from stocking and reached 50% within 9 to 15 days, at all feeding levels. Observed physical and behavioral abnormalities suggested nutritional inadequacy of the diet. The fishes in all treatments were stunted, but the over-all poor survival rate negates the possibility of using the diet for stunting over a long period of time.

The same diet was fed to wild milkfish fry to determine optimum stocking density, feeding rate, and feeding frequency. Results showed that of stocking densities tested (5, 10, 15, 20, and 25 ind/liter), fry stocked at 10 to 15 ind/liter exhibited best growth and survival. In the feeding rate experiment, milkfish fed 125, 75, 50, and 25% of their body weight per day on the first, second, third and fourth week, respectively, showed the best growth and survival. At low density and low feeding rate, animals fed four times daily showed better growth and survival. However, at high density and high feeding rate, it was better to feed them two or three times daily. Further studies are being done to confirm these results.

Knowledge of the digestive enzymes and their distribution in the digestive tract of pond-reared milkfish helps to determine the type of feed ingredient to incorporate in practical diets.

Crude extracts from various regions of the digestive tract of pond-grown milkfish were tested to determine the distribution of protein digesting enzymes. The major sites of protease secretion in milkfish are the pyloric caeca, intestines, and pancreas. In general, protease activity was higher in fishes that fed on lablab, compared with those that fed on lumut*.

The presence of trypsin in the digestive tract of milkfish that fed on lablab was confirmed. No tryptic activity was found in lumut-fed fish probably due to a trypsin inhibitor in lumut rather than the failure of the fish to secrete trypsin. This observation suggests that lumut may neither be a good food for milkfish nor a good feed ingredient unless this inhibitor is destroyed or removed.

*Filamentous green algae predominantly *Chaetomorpha*.

Ecology

Fishermen gathering milkfish fry from a collection ground in the western coast of Antique, Panay Island.

The main objectives of the Ecology Project were to: a) identify and characterize spawning, fry, and nursery grounds of milkfish and prawns, b) determine their seasonal distribution and occurrence, and c) study their food and feeding habits.

MILKFISH

The shallow shoal west of the island of Maralison, off the coast of Culasi, Antique was identified as a milkfish spawning ground, in addition to Seco Island and Cagayan Cilio identified earlier.

The southeast coast of Batbatan Island and the waters off Lipata Point in Culasi might also prove to be possible spawning grounds. The confirmation of spawning grounds off the Antique coast partly explains why the western coast of Panay is one of the best milkfish fry fishing grounds in the Philippines.

During the year, several fry grounds in Panay, Negros and Northern Mindanao were surveyed. In almost all locations studied, the fry was abundant in coastal areas which have highly productive intertidal estuaries, and nipa and mangrove swamps. While fry abound in shore waters during peak months, juveniles were found in estuarine areas of the backwaters. Massive appearance of fry along the coast shows that the fry move from the spawning areas to the nursery grounds in search of food. This implies that fry grounds are only transitional habitats for the fish.

Examination of the gut contents of fry showed intake of diatoms, copepods, and resuspended materials from the bottom. Decomposing organic matter in the habitat appeared to be the chief source of food for the fry.

Surveys on species associated with milkfish yielded over thirty species of finfish fry. These included, among others, fry of cultivable species such as mullets, siganids, snappers, and groupers.

PRAWN

Based on the occurrence of prawn spawners and postlarvae, studies showed that in their natural habitat prawns spawn all year round. Two peaks of spawning seasons were determined: February to March or June to July, and October to November. It was also observed that prawns may spawn for the first time at the mouth of bays where fully saline conditions exist; or offshore in waters up to 70 m deep, especially during succeeding spawnings.

While prawn larvae were observed offshore, during their early juvenile stages they migrate to shore waters with the incoming tide. Postlarval prawns were observed all year round with peak seasons in June to July and October to November. Postlarvae of *P. monodon* were observed all year round with peak seasons in July to August and November to December.

Adults of *P. monodon* were caught during the new moon period all year round, mainly abundant during February, August, and November.

The gut contents of *P. monodon* showed a wide range of food items like organic detritus, diatoms, algae, polychaetes, echinoderms, foraminiferans, silt and solid particles, predominantly crustaceans, molluscs, and fish, suggesting that juveniles and adults prefer crustaceans, molluscs and fish for their diet.

Natural Food

The primary concern of the Natural Food Project was to: a) isolate various food organisms, b) assess their nutritional values as feeds for larvae, and c) develop techniques for maintenance and mass culture of various natural food organisms.

PHYTOPLANKTON

Algal species were isolated from Batan, Iloilo and Hamtik waters; these included *Nitzschia* sp., *Chlorella* sp., *Monochrysis* sp., *Chaetoceros* sp., *Nannochloris* sp., and others yet to be identified. These are presently being maintained in both solid and liquid media.

The optimum conditions for growth of *Tetraselmis* sp. and *Dunaliella* sp. were determined using combinations of salinity and light intensity in various growth media. Data on the exponential growth phase (after 3 to 4 days) showed that the different culture media used had varying effects on growth. The tested combination that gave the highest density for *Tetraselmis* sp. was a salinity of 25 parts per thousand, a light intensity of 9,000 lux and Tungkang Marine Research Laboratory (TMRL) media; and for *Dunaliella* sp. a salinity of 30 parts per thousand, 9,000 lux, and TMRL media.

Penaeus monodon larvae were reared from N_6 to P_1 using 10-liter glass aquaria at a stocking density of 50 larvae/liter to evaluate various phytoplankton species as larval food.

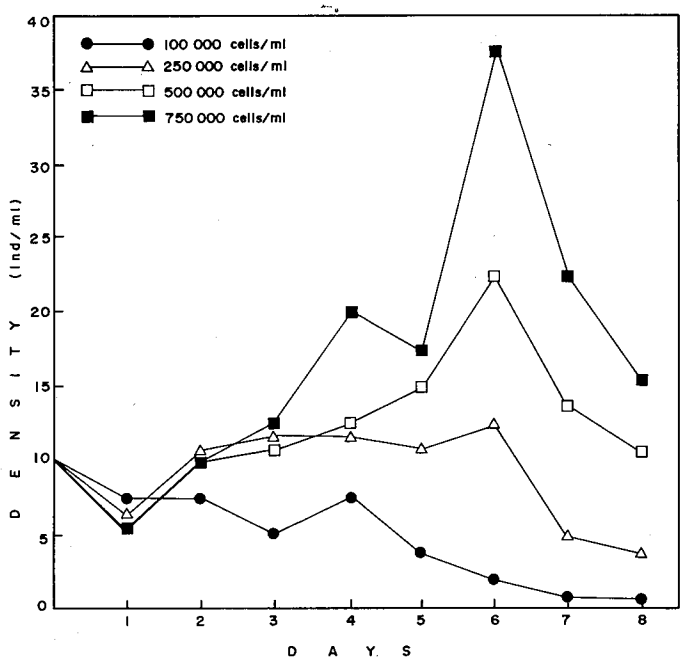


Fig. 7. Population of rotifer, *Brachionus plicatilis*, at different densities of marine *Chlorella virginica*.

Five species of phytoplankton were tested: three local strains, *Chaetoceros calcitrans* (10 x 10^4 cells/ml), *Tetraselmis* sp. (5 x 10^4 cells/ml), and *Dunaliella* sp. (5 x 10^4 cells/ml), and two imported strains, *Isochrysis galbana* (7 x 10^4 cells/ml) and *Skeletonema costatum* (10 x 10^4 cells/ml). Results showed that highest survival was obtained with larvae fed with *C. calcitrans* followed by *Dunaliella* sp. and *Tetraselmis* sp.

Milkfish fry caught from the wild were reared using 20-liter glass aquaria at a stocking density of 10 fry/liter. Five selected algal species, *Dunaliella* sp. (50 x 10^4 cells/ml), *Tetraselmis* sp. (50 x 10^3 cells/ml), *Chaetoceros calcitrans* (120 x 10^3 cells/ml), *Isochrysis galbana* (80 x 10^3 cells/ml), or *Chlorella virginica* (300 x 10^3 cells/ml) in combination with *Brachionus plicatilis* (15-20 ind/ml) were tested as food. After the 45-day rearing period, *Dunaliella* and *Brachionus* gave significantly higher survival (34.33%) and growth.

ZOOPLANKTON

Highest mean population density (6,500 ind/liter) after 7 days of culture of *Moina macrocopa* was attained when the animals were given a combination of chicken dung, bread yeast and *Scenedesmus* sp. Two feed combinations of bread yeast+ *Scenedesmus* sp. (5,300 ind/liter) and chicken dung+*Scenedesmus* sp. (4,400 ind/liter) gave slightly lower mean population density. When a single feed was used, chicken dung gave the highest density.

It was shown that *Moina* could tolerate abrupt salinity changes up to 8 parts per thousand for 3 hours. Mass culture at 5 parts per thousand using chicken manure extract resulted in mass mortalities after 2 days of culture. However, growth and reproduction were sustained even after 7 days of culture when salinity was lowered to 4 parts per thousand.

Population growth of the marine rotifer, *Brachionus plicatilis*, was observed using various feeding densities of *Chlorella virginica*. Water salinity was 28 parts per thousand. Production rates increased with increasing feeding densities. Highest production rate was obtained at feeding density of 75 x 10^4 cells/ml (Fig. 7). *B. plicatilis* fed with 25 x 10^4 cells/ml of *Chlorella* grew best at a salinity of 10 to 16 parts per thousand (Fig. 8).

Peak densities of the copepod, *Tisbintra elongata*, were attained in 5 to 6 days using *Chlorella* and baker's yeast at feeding levels of 20 to 40 x 10^3 cells/ml and 0.1 g per ton, respectively. The average density of *T. elongata* cultured in the zigzag stream unit was about 7 times higher than that in the fiberglass tanks.

An unidentified brackishwater calanoid copepod was successfully cultured and acclimated from 8 parts per thousand to 22 parts per thousand salinity. Acclimation of the spe-

cies was attained through gradual increase in salinity at a rate of 2 parts per thousand every 3 weeks. *Chlorella, Tetraselmis,* baker's yeast and chicken manure were used as food.

Mass culture of *Artemia salina* using air-water-lift raceways, modified inclined air-water-lift raceways and in tanks with bottom aeration showed no significant difference in growth and survival.

Artemia fed to milkfish fry showed that feeding level of 100% body weight (dry matter basis) is best. Preliminary tests showed that frozen and dried *Artemia* gave better growth and survival of milkfish than live *Artemia.*

Locally produced *Artemia* cysts gave better hatching percentage than any of the imported strains. A hatching average of 98% was obtained after 24 hours incubation for cysts of Leganes-grown Brazil Artemia, and 71% for Leganes-grown San Pablo Bay *Artemia* compared to 38% for mother strain Brazil *Artemia,* and 0% for Australia *Artemia.*

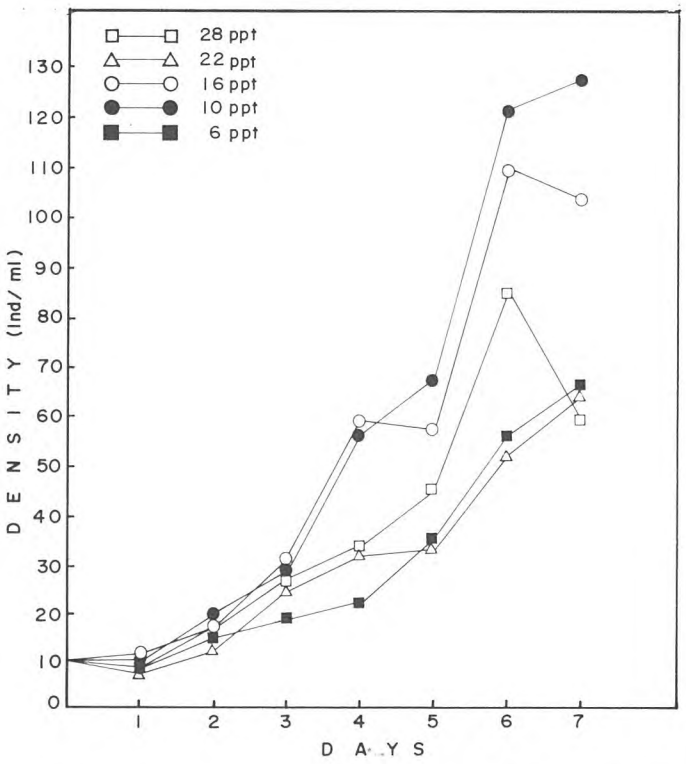
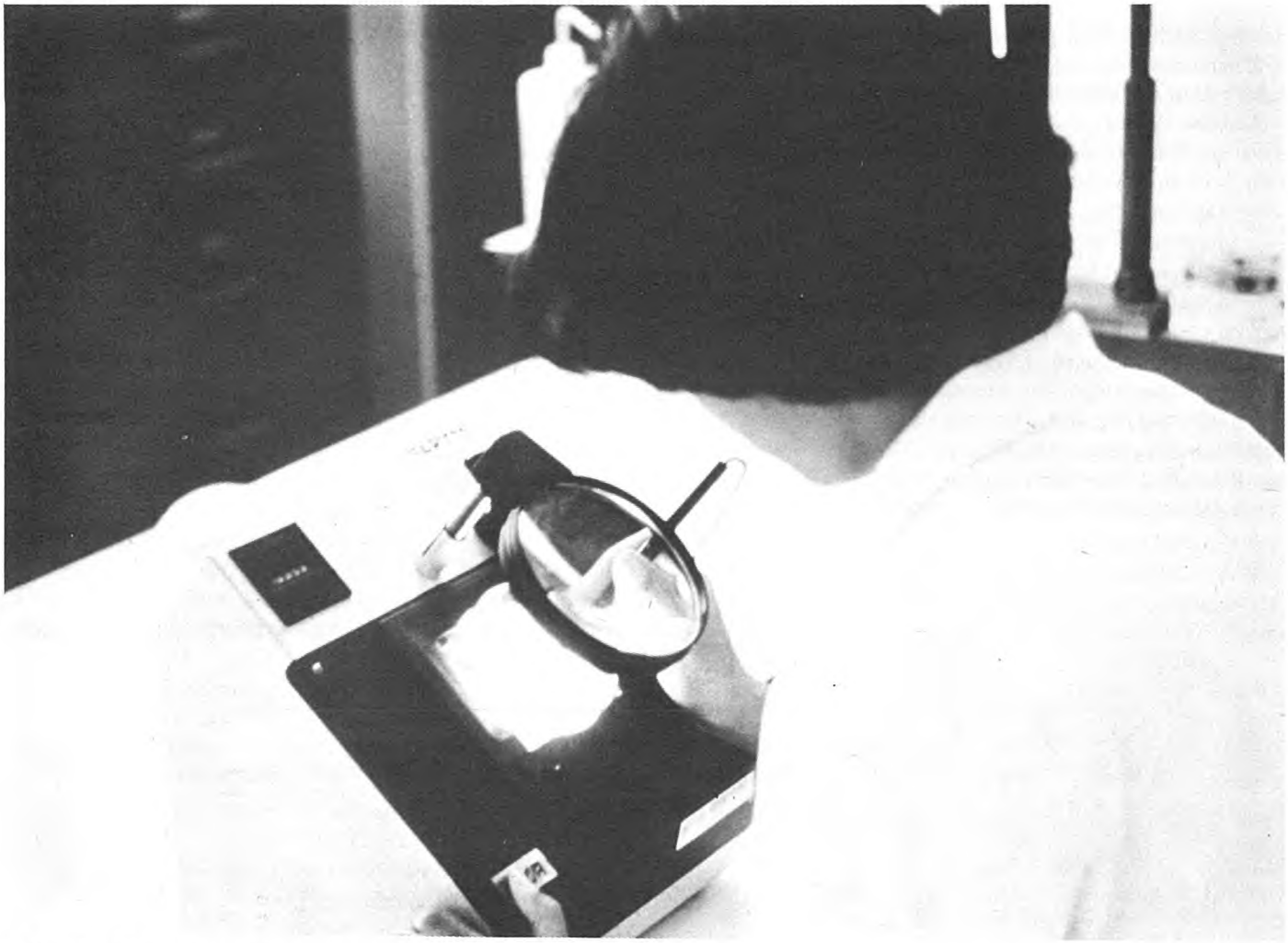


Fig. 8. Population growth of the rotifer, *Brachionus plicatilis,* **at different salinities.**

Preparation and fertilization of sea water for phytoplankton cultures.

Sampling for population estimates of high density culture of zooplankton (*Tisbintra* sp.).

Pathology



Counting of bacterial colonies isolated from diseased fish.

Research activities in the Pathology Project were aimed at a) isolation and identification of pathogens affecting cultured fish and crustacean species, b) development of prophylactic and therapeutic procedures for various diseases, and c) studies on the tolerance of these species to various therapeutic agents.

1. **Identification and control of diseases affecting wild and hatchery-reared milkfish fry.** Wild and hatchery-reared *Chanos chanos* fry cultures with high incidence of mortality were sampled. Bacterial isolation and identification were made on batches of affected fish fry showing possible indications of bacterial infection. Bacteria isolated were identified as *Vibrio* sp., *Aeromonas* sp., *Pseudomonas* sp., *Alkaligenes* sp., *Klebsiella* sp., and *Acinetobacter* sp. The first two genera were the most frequently isolated. One species of *Vibrio* was experimentally shown to be pathogenic towards wild milkfish fry. Mortalities increased with dose and exposure period.

2. *Tilapia nilotica* **fry infections.** Causes of heavy mortality of *Tilapia nilotica* fry reared at the local Bureau of Fisheries and Aquatic Resources (BFAR) station were examined. *Pseudomonas* sp. and *Salmonella* sp. were isolated from weak fry. Infection studies revealed that healthy *T. nilotica* fry became susceptible to *Pseudomonas* sp. infection after 48 hours exposure to a bacterial dose of 0.1 mg/100 g fish. *Salmonella* sp. proved to be non-virulent to the fry at the same dose.

In a second case of BFAR-reared *T. nilotica* fry that suffered heavy mortalities, *Flavobacteria* sp. and *Aeromonas* sp. appeared to be associated with the diseased fry. Pathogenicity tests are being conducted on these isolates.

3. **Epidemiology of fungal diseases of penaeid larvae.** Potential sources of the fungi *Lagenidium* sp. and *Haliphthoros* sp., both pathogenic, to hatchery-reared larvae, were investigated. No fungal isolates were obtained from diatom cultures used as food, rearing water, aeration, sand filters, hatchery rubber hose, and rearing tanks. Aborted eggs and hatched larvae, however, were positive for *Lagenidium* sp.

4. **Etiology of black disease in** *Artemia salina.* A filamentous bacterium, varying in length from a dozen cells to several hundreds, was observed attached to *Artemia* adults fed solely with fermented rice bran over prolonged periods. Although infection may have started as early as the 7th or 8th

day, it became manifest on the 10th day, when up to 20 to 25% of the *Artemia* population had been infected.

Infected adults swam listlessly owing to a heavy load of filaments which covered the whole body and gave the impression of a halo. When infection was widespread, filaments covered the thoracopods and seriously obstructed the filtering ability of the individuals. However, the extent of attachment was superficial being limited to the exoskeleton.

Transferring infected *Artemia* adults to seawater containing vigorously growing cultures of phytoplankton caused the rapid molting of the exoskeleton. The procedure eliminated the infection and appeared to control the disease. Among the phytoplankton found effective were *Dunaliella* sp., *Phaeodactylum* sp., *Tetraselmis chuii,* and *Nitzschia closterium.*

5. **Effect of formalin and fresh water on the ectoparasite, *Catigus* sp.** The ectoparasite, *Caligus* sp., infesting adult *Chanos chanos* and *Scatophagus argus* held in canvas tanks were exposed to formalin and fresh water at varying concentrations and duration of treatment. Results showed that exposure to 90 parts per million formalin for 2 hours was lethal to the parasite. Maintaining the host fish in 100% or 75% fresh water killed the parasite after 24 or 72 hours of exposure, respectively.

6. **Tolerance and histopathological response of milkfish, *Chanos chanos,* fingerlings to potassium permanganate.** After 96 hours of exposure, 50% of the milkfish fingerling population died at 1.42, 1.34, and 1.36 parts per million potassium permanganate for the first, second, and third runs, respectively.

Potassium permanganate is a known bactericide, parasiticide, oxidizer, and detoxifier. Fish exposed to the lowest concentration, 1 part per million, could tolerate the chemical even after 96 hours, but at 1.8 parts per million, the highest concentration, all the test fish were dead within 6 to 24 hours. Histopathological analyses of the gills, liver, and kidneys are still ongoing.

7. **Toxicity of Dipterex to *Chanos chanos* fry.** The toxicity of Dipterex, an organophosphate pesticide, to milkfish fry was determined. At 24, 48, 72 and 96 hours of exposure, 50% of the fry survived at 17.8, 15.0, 13.0, 11.4, and 9.3 parts per million Dipterex, respectively. The estimated safe doses and the different tolerance limits presented in Table 2 serve as a guide to fry response to Dipterex.

8. **Diagnostic services.** The Project's diagnostic services processed a total of 45 pathological case referrals: 24 fish, 17 prawn, 1 oyster, 1 *Artemia,* and 2 soil. A set of mussel specimens was examined for coliform contamination. Quantitative bacterial load of 7 water samples was determined.

Table 2. Tolerance limits of *Chanos chanos* fry to Dipterex

Period of exposure (hour)	Safe dose* (ppm)	Tolerance limits (ppm) 10	50	90
6	16	–	–	–
12	16	–	–	–
24	12	13.46	17.78	25.79
48	7	11.59	15.13	20.17
72	7	7.24	11.37	20.00
96	5	6.05	9.30	14.88

* Based on Dunnett's Test at 96% level of significance.

Aquaculture Engineering

The Aquaculture Engineering Project aimed to improve equipment and facilities for growing important species. It also tried to find alternative sources of energy to reduce aquaculture production costs. During the year, six studies were conducted.

1. **Design and development of windmill.** An eight-blade windmill was made out of G.I. sheets coupled to a single acting reciprocating pump. The power output of the windmill-pump combination was measured by the length of time it took water to fill a 20-liter pail. Results showed that: 1) for wind speeds up to 2 m/second (sec), the windmill started almost instantly, but the pump did not lift water; 2) for wind speeds from 2 to 7.7 m/sec, the pump performed satisfactorily, with an average discharge of 26.7 liters/minute (min); and 3) for wind speeds beyond 8 m/sec, the windmill was cut off from the pump. However, the windmill structure was able to withstand the strong winds resulting from three typhoons.

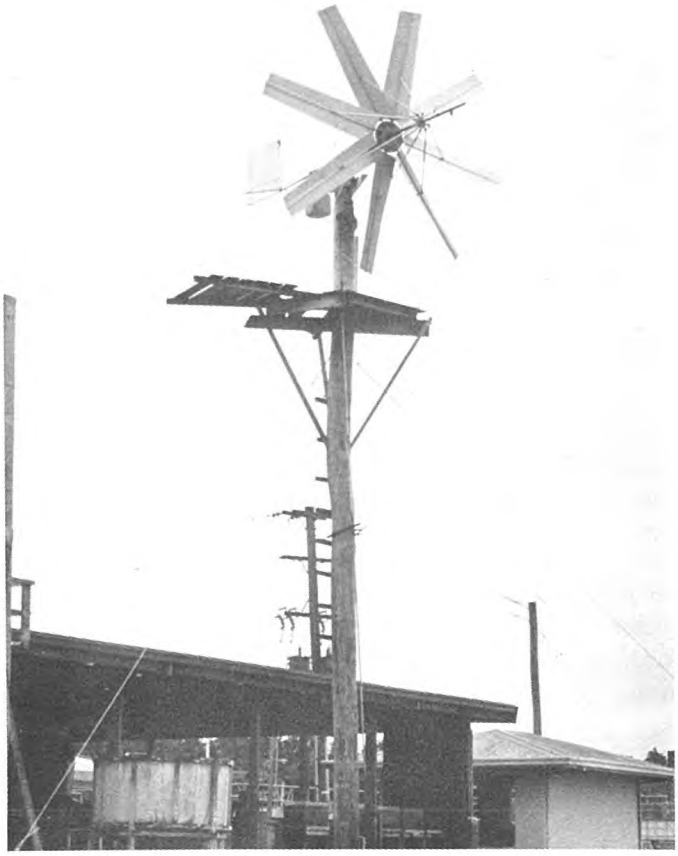
2. **Design and development of culture tank systems.** Initially, existing equipment for testing were evaluated for suitability. An air meter was refitted in small plastic tubes to measure airflow. Although it gave satisfactory results, it could not be used as a standard instrument. The common household water meter was also found to be unreliable as air flow meter.

In another experiment, it was observed that a small blower (140 watts) did not yield the pressure required in aquaculture operations.

3. **Aeration efficiencies.** Volumetric oxygen transfer rates were evaluated in 1000-liter and 400-liter fiberglass tanks using airstones and perforated pipes as aeration devices. Sodium sulfite was used in deoxygenating the system. Rates of increase in dissolved oxygen concentration were determined after 3 and 5 hours of aeration. Results showed that perforated pipes performed better than airstones.

4. **Nursery tank biofilters; locally available materials as filter components in recycling systems.** The efficiency of indigenous materials such as coconut husks and woven bamboo strips (amakan) as nursery tank biofilters was studied and compared with a sand filter. Coconut husks proved to be the most efficient in removing biochemical oxygen demand (BOD) but did not remove ammonia. Bamboo strips were most efficient in removing the latter compound. However, in all cases, the sand filter ranked second.

5. **Performance of recirculating systems for hatchery and broodstock tanks.** The following recirculating systems for culture tanks were evaluated: biological filtration zigzag stream, sedimentation, rotating air lift and simple air lift. A system using airstones with no provision for recirculation served as control. Preliminary results indicated that prawn larvae could be successfully reared in tanks with facilities for water recirculation.



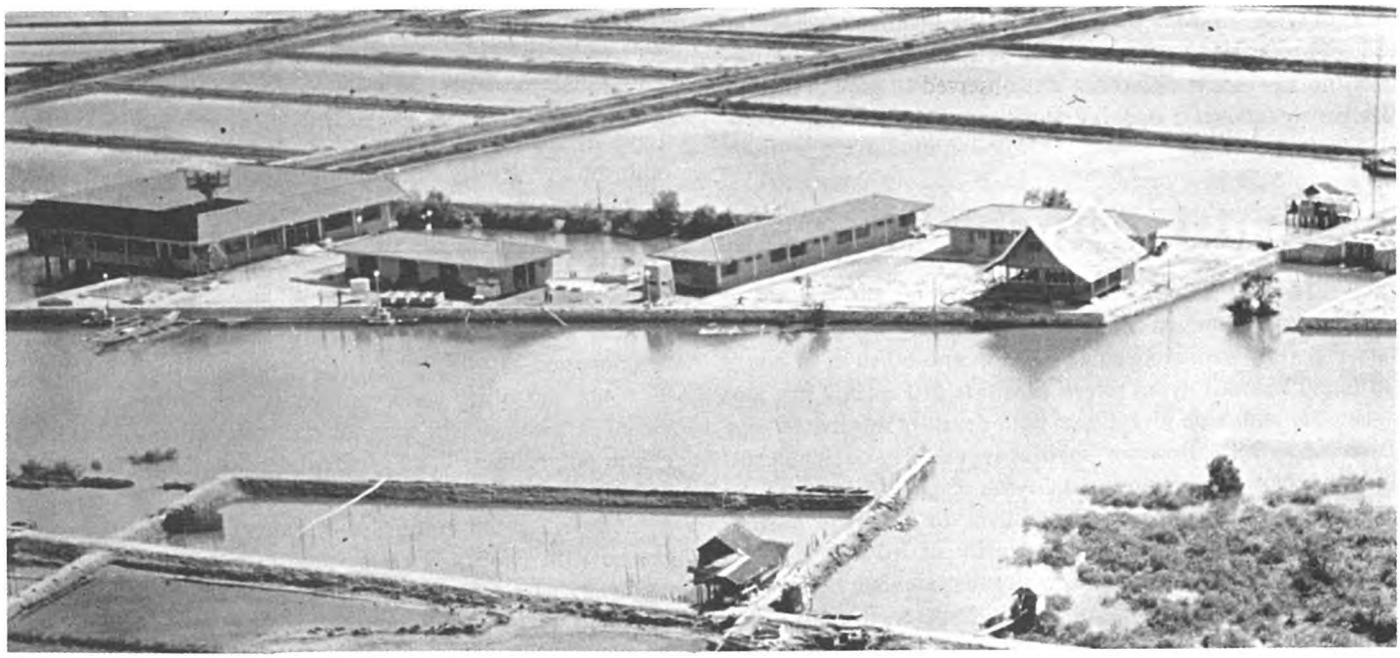
Intended as an alternative energy source, this windmill was designed to serve the water requirements of the small-scale prawn hatchery.

The performance of broodstock tank recirculating systems with biological filters was assessed. With biofilter preconditioning, biological filtration proved to be successful in meeting water quality requirements. Nitrification was satisfactory with ammonia levels lower than 1 part per million. The pH values in the biofilter effluent was maintained between 7.8 to 8.3 while dissolved oxygen levels decreased due to nitrifying activity in the filter.

6. **Low-cost water treatment systems for hatcheries.** A study was conducted to assess the efficiency of existing primary sand filter for seawater supply to the hatcheries under both normal and adverse weather conditions. Results suggested that during stormy weather, water quality parameters deteriorated, making water supply unsuitable for hatchery operations.

The efficiency of alternative materials as filter components was also determined. Coralline sand, burnt rice husk and ordinary sand were compared. Although turbidity removals were highly satisfactory for all materials, complete removal of algae was observed only with burnt rice husk. Ordinary sand and burnt rice husk were found more effective in removing bacteria than coralline sand.

Leganes Research Station



The Leganes Research Station in Iloilo Province.

The activities of the Leganes Research Station strongly complement those of the Tigbauan Station. Its location is considered highly suitable for brackishwater aquaculture research, training, and extension programs.

The Station hopes to accelerate aquaculture development by testing appropriate and economical technology packages for the production of commercially important species. In 1980, the major research activities of the station concentrated on the following: 1) culture technology, 2) feeds and feeding, 3) seed production and broodstock development. These projects, which cover various aspects of brackishwater propagation of milkfish, prawns, and other culturable species, were carried out in the 96-hectare Leganes, Iloilo fishpond area.

Finfish Culture

1. **Effects of stocking density and supplemental feeding on milkfish fingerling production.** Milkfish fry were stocked at (a) 50 fry/sq m with no supplemental feeding and at 75 fry/sq m with (b) no supplemental feeding, (c) feeding with a formulated diet, and (d) feeding with rice bran. After 45 days of culture, fingerlings given rice bran showed the highest survival rate of 59.8% followed by 45.3% for fry at 75/sq m without supplemental feeding. Fish stocked at 75 fry/sq m and fed with the formulated diet had the highest mean body weight gain (Fig. 9). However, survival of fry fed with formulated diet was low at 37.8% and comparable to those stocked at 50 fry/sq m without supplemental feeding (34.8%).

2. **Growth and survival rates of hatchery-reared vs. wild milkfish fry grown to fingerling size in earthen nursery ponds.** Hatchery-reared fry from the Tigbauan Research Station and wild milkfish fry were stocked at 30/sq m. To sustain growth of lablab which was grown prior to stocking, inorganic fertilizer (16-20-0) was applied every 15 days. No significant difference in growth and survival between hatchery-reared and wild fry after sixty days of culture was observed. Final mean weight and percentage survival were 2.11 g and 61.5%, respectively, for the hatchery-reared fry and 1.88 g and 62.9%, respectively, for the wild fry.

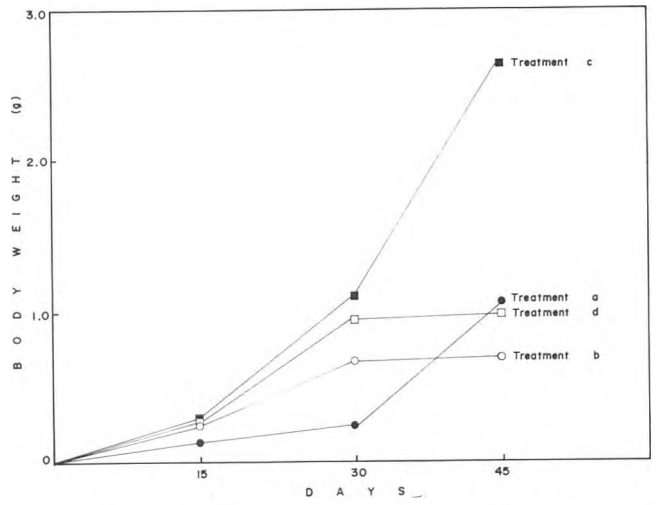


Fig. 9. Mean body weight of milkfish fry *Chanos chanos* stocked at a) 50 fry/sq m without supplemental feeding, b) 75 fry/sq m without supplemental feeding, c) 75 fry/sq m with artificial diet, and d) 75 fry/sq m fed with rice bran in 144-sq m ponds.

3. **Preliminary culture studies on grey mullet, *Mugil cephalus*.** Grey mullet was grown at stocking densities of 2,500 and 3,000/ha for 120 days using the lablab method. Survival rate of fish stocked at 3,000/ha was significantly higher (53.6%) compared to those stocked at 2,500/ha (32.6%). However, no significant difference was observed in growth rate of fish between the two stocking densities.

Prawn Culture

Effect of a nylon screen substrate on the survival of hatchery-reared prawn fry in earthen ponds. *P. monodon* postlarvae (P_4P_5) were stocked at 40/sq m and 60/sq m in ponds with and without nylon screen substrate (40 cm x 2 m). Survival of *P. monodon* juveniles at both densities was low ranging from 3.4 to 9.8%. However, survival appeared to be significantly higher in ponds provided with nylon screen substrates.

In a similar experiment, "putian" or *P. indicus* postlarvae (P_4P_5) were stocked at a density of 40/sq m. Better mean survival (32.4%) in ponds with substrate than those without substrate (21.54%) was obtained. However, this difference was not significant.

Polyculture

1. **Survival, growth and production of sugpo (*P. monodon*) and putian (*P. indicus*) at different density combinations with milkfish.** Sugpo and putian were grown at different stocking density combinations with milkfish as shown in Table 3. The presence of either *P. monodon* or *P. indicus*, or both, at any density ratio did not significantly affect survival of milkfish. *P. monodon* survival was inversely related to its stocking density. *P. indicus* survival followed the same trend but was adversely affected by a higher stocking density of *P. monodon*. When only either *P. monodon* or *P. indicus* was stocked with milkfish, lowest survival of each prawn species was obtained.

On the other hand, no significant difference was observed in mean weight gain among treatments for all the species in polyculture. Total gross production ranged from 494.4 kg/ha/crop (Treatment E) to 549.9 kg/ha/crop (Treatment C).

2. **Integrated culture of *P. indicus*, *P. monodon* and *C. chanos* with poultry.** Twelve 1,000 sq m ponds were stocked uniformly with 600 *P. indicus* juveniles, 200 *P. monodon* juveniles and 100 milkfish fingerlings. Each of six ponds had a chicken house with 40 broilers.

Table 3. Summary of stocking, harvest and total gross production of *C. chanos*, *P. monodon* and *P. indicus* in earthen ponds at different stocking combinations with three replicates/treatment.

Treatment	Species combination	Stocking (no./500 sq m)	Mean survival rate (%)	Gross production (kg/ha/crop)	Total gross production (kg/ha/crop)
A	*C. chanos*	100	96.3	516.4	546.4
	P. monodon	300	13.3 *	12.4	
	P. indicus	100	52.3 +	17.6	
B	*C. chanos*	100	94.3	475.1	542.9
	P. monodon	200	24.0 *	27.0	
	P. indicus	200	83.0 +	40.4	
C	*C. chanos*	100	89.3	473.8	549.9
	P. monodon	100	61.3 *	22.7	
	P. indicus	300	64.0 +	53.4	
D	*C. chanos*	100	86.3	457.9	507.1
	P. monodon	0			
	P. indicus	400	47.0 +	49.2	
E	*C. chanos*	100	93.6	483.7	495.4
	P. monodon	400	12.0 *	10.7	
	P. indicus	0			

* + Significantly different values at $P > 0.05$

After one month of culture, milkfish attained better mean weight gain in ponds provided with chickens compared to those without. Likewise, *P. indicus* and *P. monodon* attained better mean weight gain after 3 months of culture in ponds with chickens. Chicken broilers grew to expected size in two months of culture with 96% survival.

3. **Integration of *Artemia* production with salt production and milkfish/prawn culture in earthen salt ponds.** A 0.5-ha pond system consisting of a series of reservoir, evaporation, concentration and crystallization ponds, was used for *Artemia* and salt production during the dry season and milkfish and prawn production during the rainy months.

Experimental cultures of Brazil and San Pablo Bay (SPB) *Artemia* were established in 60-sq m ponds. After two months, a tenfold increase from an initial density of 10,000 nauplii/sq m was observed for both the Brazil and SPB *Artemia* strains. Adult *Artemia* consisted mostly of females in ponds stocked with the Brazil strain and males in ponds with the SPB strain. Mean weights for Brazil and SPB *Artemia* were 7.1 mg and 6.5 mg, respectively, indicating favorable growth in ponds even with low plankton counts. In laboratory cultures, the highest individual weight recorded was 1.0 mg.

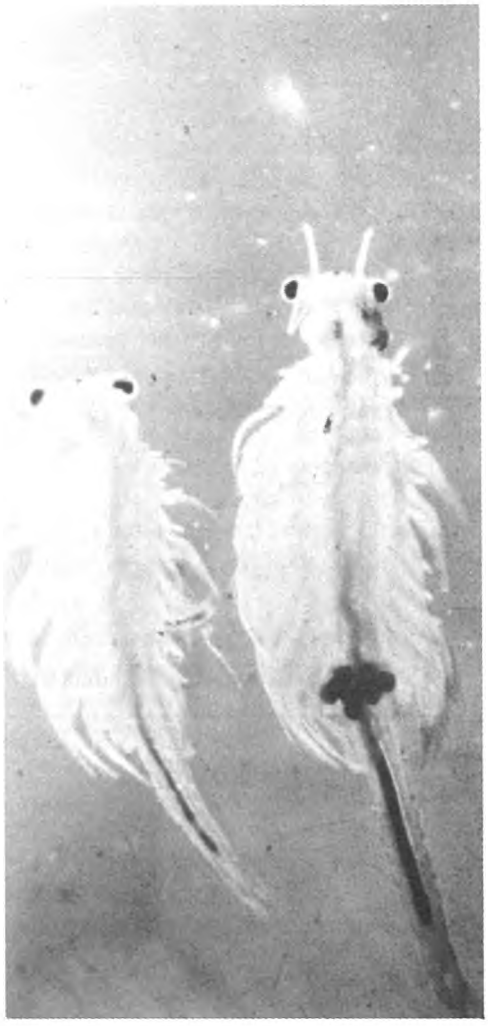
Salt production was based on the traditional solar method where seawater is pumped to a reservoir, passed through a series of evaporation ponds to increase salinity and finally concentrated in the crystallization pond for daily collection of salt. Approximately 5 tons of salt was produced during a one-month period.

A total of 122.75 kg milkfish and 2.02 kg prawn were harvested from the ponds during the rainy season. Stocking density was 3,000 milkfish fingerlings + 5,000 prawn juveniles/ha. Management of ponds was based on the lablab method.

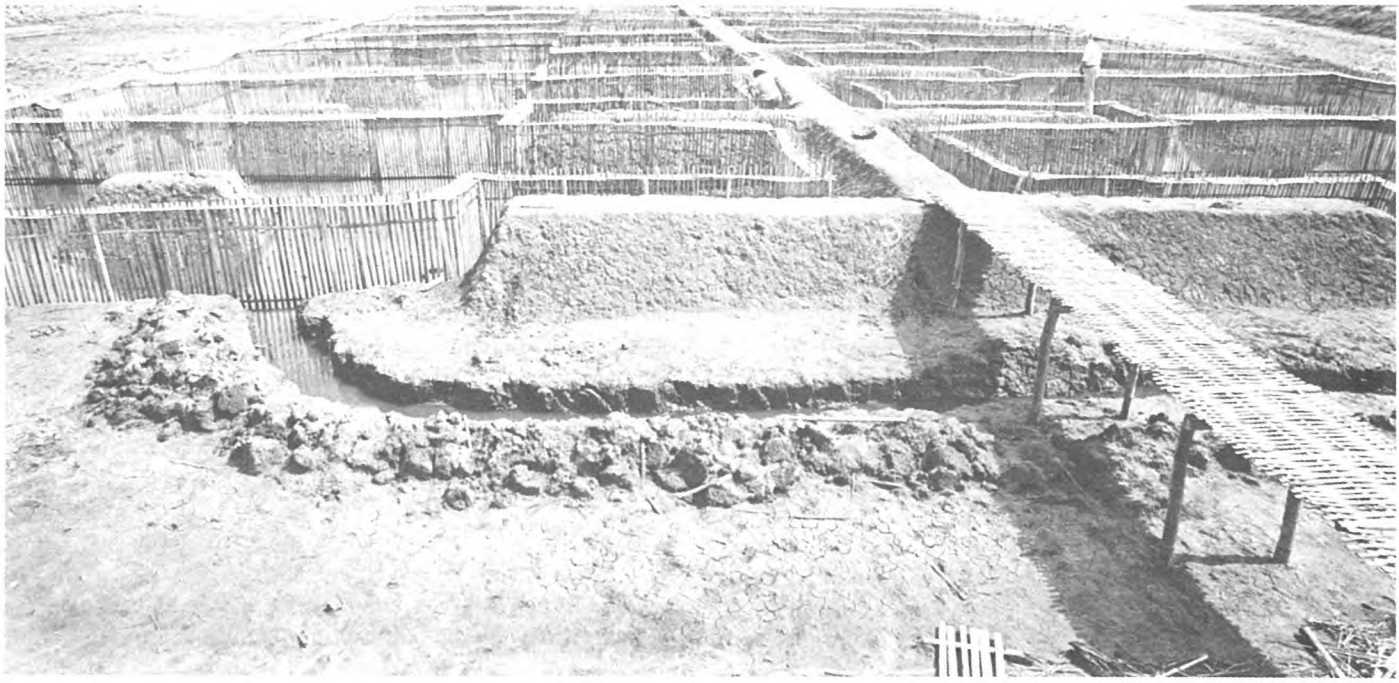
In a separate study on the effect of supplemental feeding of milkfish with live adult *Artemia* for two months, milkfish attained a mean weight gain of 110.8 g from an initial mean weight of 5.2 g. Lablab-fed milkfish had a mean weight gain of 95.4 g from an initial weight of 5.4 g.

These results show the feasibility of mass producing *Artemia* in ponds. Economic benefits may be obtained by integrating *Artemia* production with other aquaculture activities.

***Artemia* rearing is integrated with salt production and milkfish/prawn culture in earthen ponds. Dried coconut fronds provide shelter to *Artemia* nauplii and adults.**



Male (left) and female cyst-bearing *Artemia* produced in earthen ponds.



Experimental ponds for growing mudcrab, *Scylla serrata.*

Other Studies

1. **Culture of mud crab, *Scylla serrata,* at different stocking densities in brackishwater ponds.** Mud crab was grown for 90 days at four stocking densities: 5,000, 10,000, 15,000 and 20,000 ind/ha and given tilapia as supplementary feed every other day at 6 to 10% of body weight. Crabs stocked at 5,000 ind/ha yielded the highest survival of 87.33%, relative growth increment of 2.28 g/day/crab and best feed conversion value of 1.72 with corresponding net production of 924.76 kg/ha/crop (Table 4). Assuming at least three croppings in a year, a net production of about 2.9 tons/ha can be achieved at this stocking rate.

2. **Screening of potential feedstuff for mud crab, *Scylla serrata,* culture in ponds.** The potential of trash fish, mussel meat, sweet potato trimmings and filamentous green algae as feed for mud crab in ponds was investigated. In the early stages of culture, sweet potato trimmings and filamentous algae compared favorably with trash fish and mussel meat. After 120 days, crabs fed with trash fish daily gave highest net yield of 473 kg/ha and survival of 61.3%. Reducing the feeding frequency of trash fish to once every two days gave similar production and survival values, thus, the highest feed conversion ratio of 1:3.2.

3. **The feasibility of using mechanical agitation to replace standard aeration in larval rearing of *P. monodon* was studied.** Initial trials showing postlarval survival rates ranging from 54.3 to 59.5% in water mechanically agitated at various intervals are encouraging.

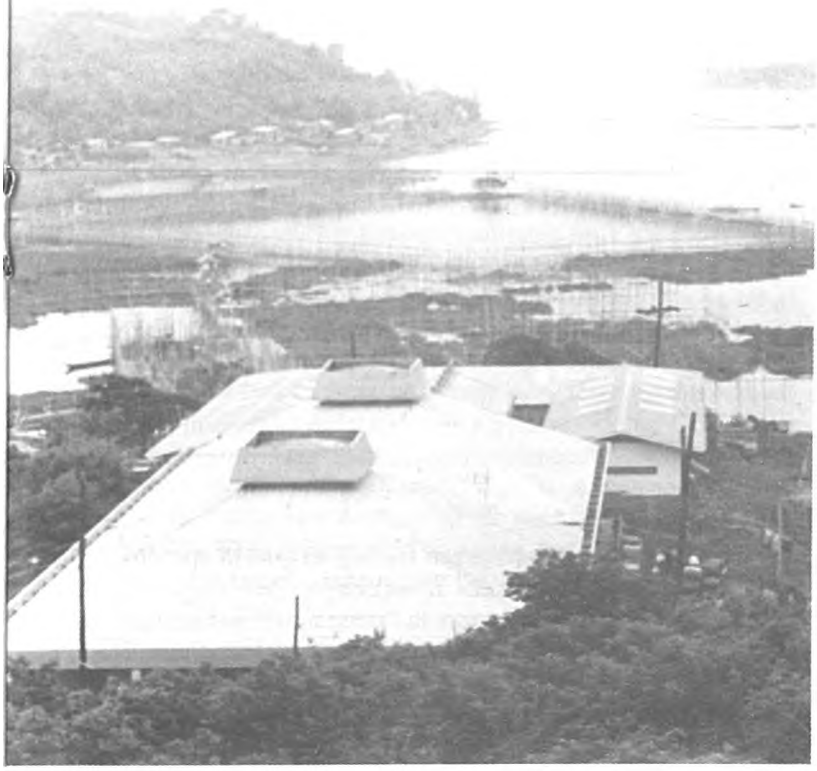
In addition, preliminary studies on maturation, broodstock maintenance, and larval rearing of the mud crab, *Scylla serrata,* were conducted.

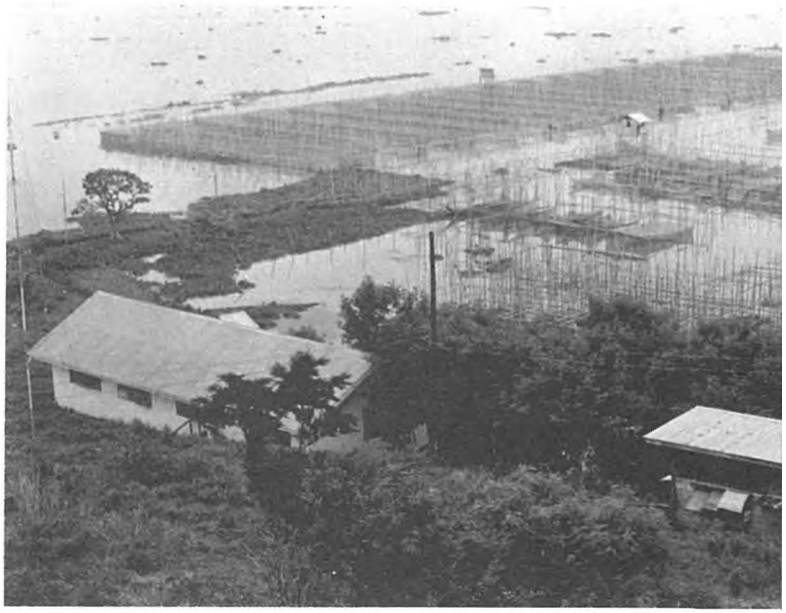
Table 4. Stocking and harvest data of mudcrab, *Scylla serrata* at four stocking densities in 100-sq m ponds.

Treatment	Stocking (no./100 sq m)	Harvest no. recovered	Average wt. (g)	Survival rate (%)	Net production (g)	Relative growth increment (g/day/crab)	Feed conversion value
I	50	43	231.60^{a}	87.33^{a}	9241.71^{b}	2.28^{a}	1.72^{a}
II	100	52	196.63^{b}	52.00^{b}	9130.58^{c}	1.89^{b}	2.16^{b}
III	150	57	171.11^{d}	37.77^{c}	8338.58^{d}	1.61^{d}	3.85^{c}
IV	200	62	178.11^{c}	31.00^{d}	9764.74^{a}	1.69^{c}	4.04^{d}

Treatment means with the same superscript are not significantly different ($P > 0.05$).

Binangonan Research Station





The Binangonan Research Station at Tapao Point, Rizal Province.

In line with the program directions of the Department, and upon consultation with fishpen operators in Laguna de Bay, the Binangonan Research Station formulated projects aimed at optimizing production of various farming systems in freshwater.

During the year, the Station implemented studies under six major projects, namely: milkfish nursery, tilapia culture, *Penaeus monodon* farming, carp culture, polyculture, *Macrobrachium* larval rearing, and limnology. In addition, field testing of *P. monodon* farming in Laguna de Bay was implemented in collaboration with the Bureau of Fisheries and Aquatic Resources.

Milkfish Nursery

1. **Effect of stocking density and duration of acclimation on the survival of milkfish fry.** Wild milkfish fry held in brackish water (10 to 13 parts per thousand) were acclimated in fresh water for 2 days at four stocking densities of 1,000, 1,500, 2,000, and 2,500 fry/basin (30-liter capacity). Survival rates at the various stocking densities ranged from 89.6 to 97.4% and were not significantly different.

In another experiment, wild milkfish fry were stocked at 1,500/basin and acclimated over periods of 2, 3 and 4 days. The duration of acclimation significantly affected survival rates. After 2, 3 and 4 days of acclimation, survival rates were 94, 56 and 52%, respectively.

2. **Effect of artificial feeds on growth and survival of milkfish fry in freshwater environment.** Wild milkfish fry held in aquaria with fresh water were fed with four formulated dry diets (Table 5), *Moina,* or blended water hyacinth leaves. The fry fed with artificial diets attained 83 to 95% survival rates and 0.16 to 0.18 g mean weight gains. Those fed with *Moina* and blended water hyacinth leaves had much lower growth and survival. The four diets containing 40% crude protein were adequate for the fry. Substitution of up to 5% crude protein by soybean meal and/or ipil-ipil leaf meal did not affect growth but diets containing ipil-ipil leaf meal gave slightly lower survival rates.

Milkfish fry in cages attained fingerling size (5 cm total length) in 6 weeks. Supplemental feeding of the fry improved survival but not growth since the plankton biomass in the rearing cages was high (24 to 43 g/cu m).

Table 5. Percentage composition of the formulated dry diets fed to milkfish (*Chanos chanos*) fry.

Ingredients	Diet			
	M-1	M-2	M-3	M-4
Fish meal	66.0	56.6	56.6	57.5
Soybean meal		11.4	4.6	
Ipil-ipil leaf meal			12.5	18.8
Shrimp meal	9.0	9.0	9.0	9.0
Rice bran	10.7	8.7	3.0	0.4
Cod liver oil	2.5	2.5	2.5	2.5
Vegetable oil	2.5	2.5	2.5	2.5
Sago palm starch (binder)	5.0	5.0	5.0	5.0
Mineral mix [1]	3.6	3.6	3.6	3.6
Vitamin mix [1]	0.69	0.69	0.69	0.69
BHT	0.04	0.04	0.04	0.04
Nutrients				
Estimated crude protein (%)	40.0	40.0	40.0	40.0
Digestible energy (Kcal/100 g diet) [2]	250	250	250	250

[1] For practical and complete diets

[2] Adopted from values for channel catfish: 3.5 Kcal/g protein, 8.1 Kcal/g fat, 2.5 Kcal/g carbonhydrates

Tilapia Culture

1. **Effect of sex ratio on fry production of *Tilapia nilotica* in cages.** The total cumulative fry production of *T. nilotica* in cages stocked at different sex ratios of breeders after 7 months was highest (17,842) at one male to seven females, followed by production of 15,767 at one male to five females. Lowest fry production was at one male to three females and one male to nine females.

2. **Effect of varying dietary crude protein levels on growth and spawning frequency of *T. nilotica* breeders.** Six practical dry diets with varying crude protein levels were fed to male and female breeders. In general, mean weight gain for both males and females increased as the dietary crude protein level was increased up to 40%, but decreased with 50% crude protein. Highest spawning frequency was obtained from females fed with 50% crude protein which may account for their lower growth rate.

3. **Effects of stocking density and supplemental feeding on growth and survival of *T. nilotica* fry.** *T nilotica* fry were reared in cages at stocking densities of 1,000, 2,000, and 3,000/cu m. Fry in three of the cages were fed with fine rice bran while fry in the other three cages were not fed.

After 8 weeks, survival rate and growth of fry were highest at 1,000/cu m. Supplemental feeding with fine rice bran showed no significant effect on survival and growth.

4. **Growth and survival of *T. nilotica* fry in fertilized "green water" with varying phytoplankton densities.** *T. nilotica* fry were grown in "green water" at the following phytoplankton concentrations: a) high, 150,000 to 175,000 cells/ml; b) moderate, 90,000 to 120,000 cells/ml; and c) low, 50,000 to 60,000 cells/ml.

Increased algal densities enhanced growth of *T. nilotica* fry (Fig. 10). Growth was poor at the low cell density and in the control fed with rice bran.

Survival was highest (93%) at moderate to high algal densities. High mortality was observed at low cell densities and in the control.

Gut analysis revealed a proportionate increase in algal food intake with increasing phytoplankton density in the rearing medium.

5. **Effect of phytoplankton feeding on growth and survival of Red tilapia and normal *T. nilotica* fry.** Red tilapia and normal *T. nilotica* fry were grown in "green water" with a high plytoplankton density (150,000 to 175,000 cells/ml). Control lots were given rice bran.

Marked differences in growth and survival were observed between treated lots maintained on phytoplankton as natural food and control lots given rice bran for two months. Survival was high for both normal (67.3%) and Red (52.7%) tilapia grown in "green water" in contrast to those grown in rice bran (0 to 2%). Likewise, growth rates were better for fry reared in "green water" compared to controls.

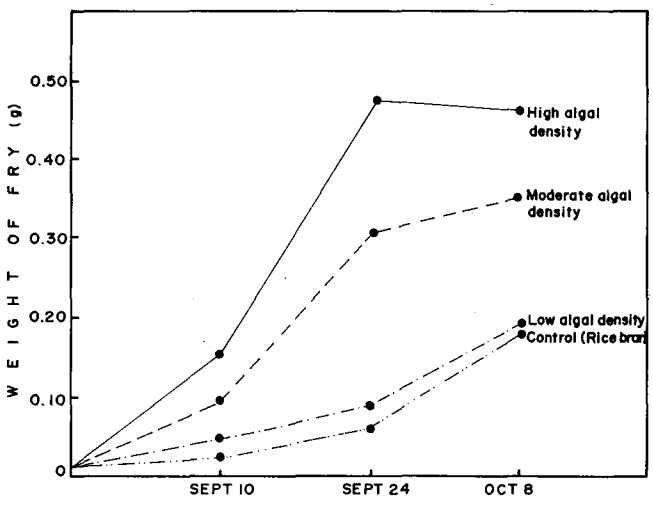


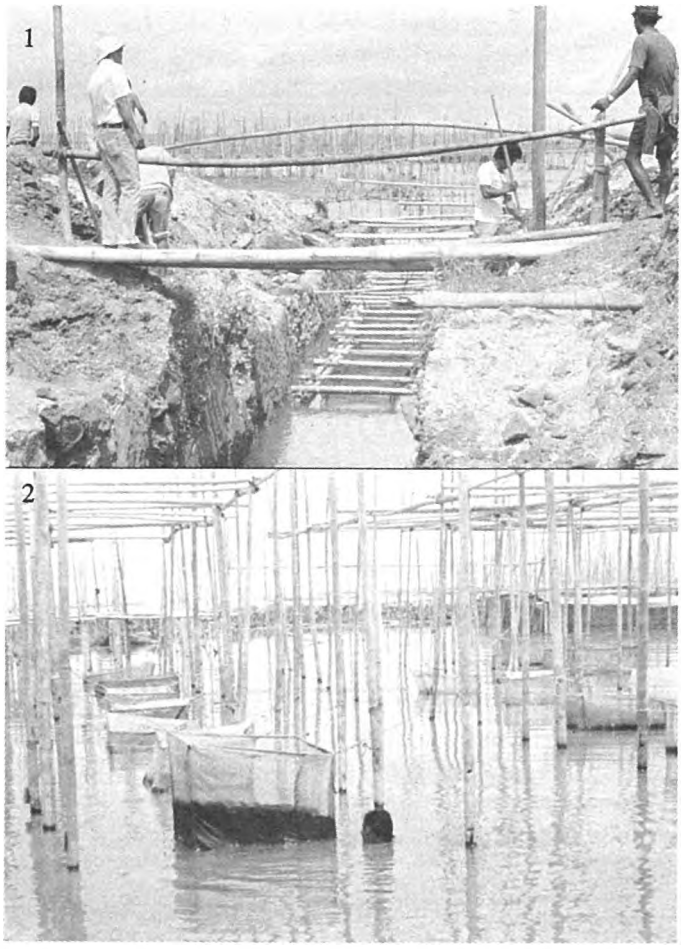
Fig. 10. Growth of *Tilapia nilotica* fry given varying levels of phytoplankton as natural feed.

6. **Cage culture of *T. aurea* x *T. nilotica* hybrids in Laguna Lake.** Hybrids of reciprocal crosses between *T. aurea* and *T. nilotica* were stocked in cages with or without feeding. However, the two crosses were not significantly different in bulk weight per cage, average weight per fish, and percentage survival. Supplemental feeding had no significant effect on growth.

7. **Selective breeding of Red Tilapia with *T. nilotica* and *T. mossambica.*** The male Red tilapia crossed with either *T. nilotica* from Los Banos, Laguna or *T. mossambica* selection of the Station produced 50% Red and 50% normal offspring. However, in the case of Red tilapia crossed with *T. nilotica* from Taal, Batangas, the ratio of Red to normal was 3:1. The Red crossed with *T. aurea* produced 2 Red to 1 normal.

Crossbreeding the male Red tilapia with either *T. mossambica* or Los Banos *T. nilotica* produced offspring that showed better growth performance than the parents.

8. **Effect of stocking density on survival and growth of *T. nilotica* fingerlings in cages.** *T. nilotica* fingerlings were grown to marketable size in one-cu m cages in Laguna Lake at densities of 50, 100, 150 and 200/cu m. A high recovery rate (98 to 100%) was obtained at all stocking densities after 4 months. Mean weights and lengths of fish at 50 and 100/cu m were significantly higher than those stocked at 150 and 200/cu m (Fig. 11).



1. Constructing a canal across the land bridge of Tapao Point; experiments in this canal showed that tilapia can be reared at high densities in narrow waterways with low dissolved oxygen content. 2. Net cages for tilapia production.

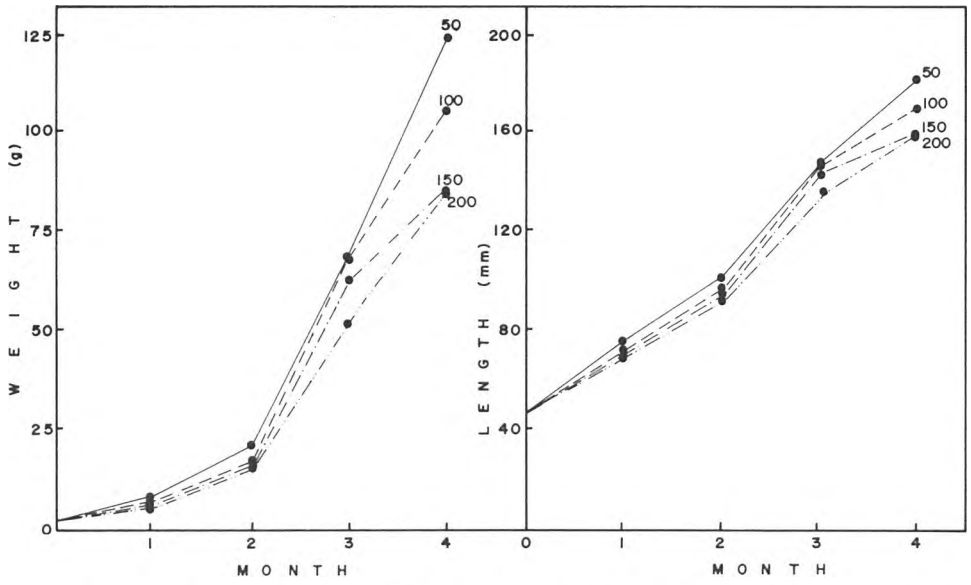


Fig. 11. Growth curves of *Tilapia nilotica* in cages at four stocking densities (ind/cu m).

P. monodon Farming

1. **Effects of stocking density and types of supplemental feed on the cage farming of *P. monodon* in Laguna Lake.** *P. monodon* postlarvae (P_{35} to P_{50}) from the Tigbauan Research Station were conditioned in fresh water and stocked in the lake for cage farming.

Growth of *P. monodon* in the lake was slow from June to November. Mean weights ranged from 10.4 to 20.8 g over a 5-month rearing period. Mean survival values obtained were 16 to 38%.

Best results were observed when *P. monodon* was stocked at 15/sq m and given raw trash fish. The other treatment combinations of higher stocking density (30/sq m) and fed formulated diet gave slightly lower growth and survival, but differences among treatments were not significant.

2. **Effects of different types and amounts of binders on water stability of prawn pellets.** Prawn pellets containing 5% of either *Eucheuma,* cassava flour, all-purpose flour or purified sago palm starch as binder were evaluated for water stability at different time intervals in continuously aerated fresh water. The pellets with *Eucheuma,* cassava flour, and all-purpose flour were equally stable (Fig. 12). Pellets bound with sago palm starch were the least stable. In another experiment, *Eucheuma,* cassava flour, and all-purpose flour were used as binders at varying amounts (1, 2, 3, and 5%) in the pellets. Regardless of the amount, all-purpose flour gave slightly more stable pellets compared with *Eucheuma.* Pellet stability generally decreased slightly as the amount of binder, regardless of type, was increased from 3 to 5%.

Monitoring of limnological parameters in Laguna de Bay.

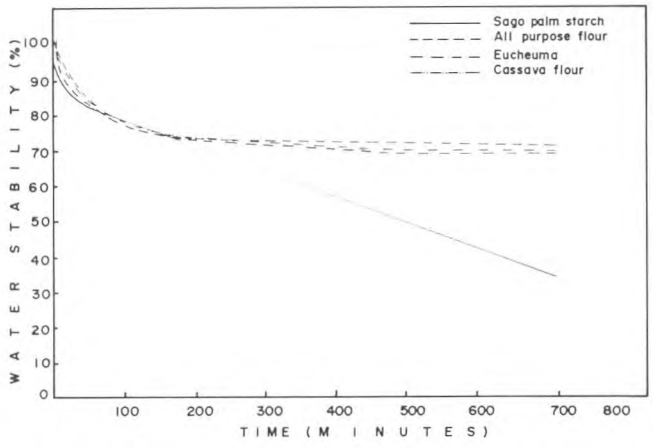
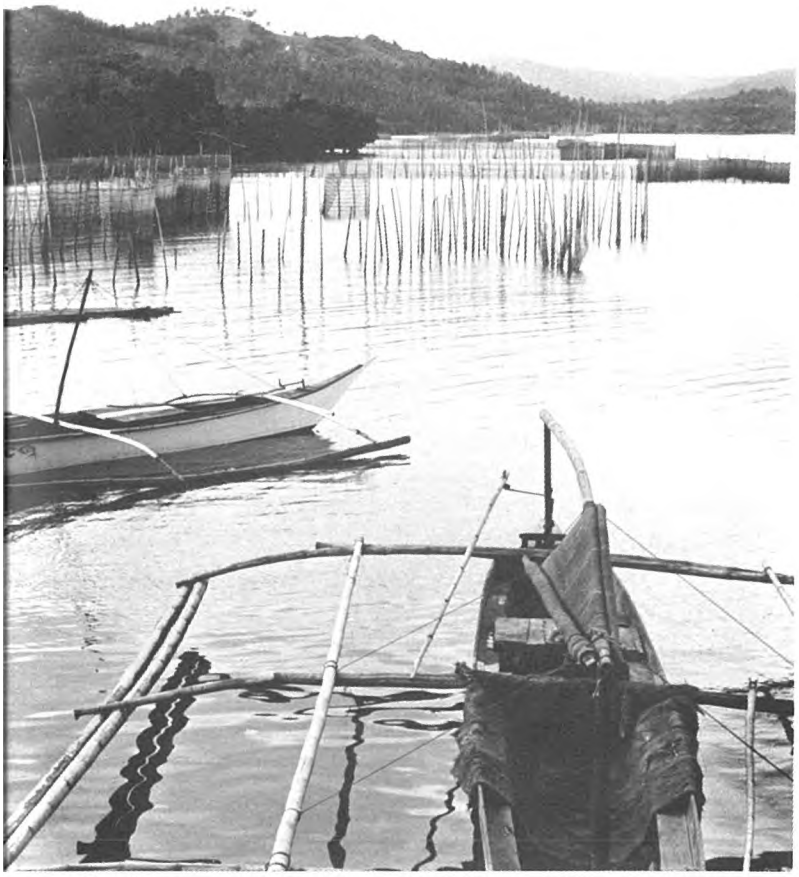


Fig. 12. Water stability of pellets containing four types of binder tested at various time intervals.

Carp Culture

1. **Induced Breeding of *Cyprinus carpio* using carp pituitary homogenates.** Four trials on induced breeding of *C. carpio* were conducted using common carp pituitary homogenates in a single injection. Fecundity ranged from 12, 000 to 27,000/breeder. Spawning occurred 6 to 9 hours after injection. Fertilization rate ranged from 60 to 85% with estimated total number of hatchlings from 12,000 to 50,000.

2. **Effects of stocking density and supplemental feeds on growth and survival of *Cyprinus carpio* fingerlings in cages.** The effects of supplemental feeding and stocking density on growth and survival of common carp fingerlings were investigated. Daily growth rate and percent daily increase of fish biomass tended to increase with decreasing stocking densities.



Supplemental feeds (35% crude protein in dried pellet form) did not yield marked differences in growth at 50, 150, and 250/cu m. Net production was highest at 150 kg/cu m with and without supplemental feeding.

3. **Optimum stocking density for rearing carp fry to fingerlings in cages.** Common carp fry were reared in nursery cages using five stocking densities: 100, 200, 300, 400, and 500/cu m. Growth and survival did not vary significantly in the different treatments. Consequently, a higher profit per cage was obtained at higher densities.

Polyculture

1. **Polyculture of *Tilapia nilotica* and carps in cages in Laguna de Bay.** *T. nilotica* was grown in polyculture with different carp species (silver, bighead, grass, and common carp) in cages in Laguna Lake. Selective harvesting or "thinning" (with replenishment) of tilapia was done at intervals of 3, 4, and 6 months.

Selective harvesting of *T. nilotica* after 6 months gave the highest production of 189.9 kg/cage or an 88.5% recovery from the original stock. Production of *T. nilotica* after 3 and 4 months were 187.6 and 83.9 kg/cage, respectively. Recovery of tilapia exceeded 100% in all treatments as a result of intrusion of fry from the open waters.

Average growth rate was highest in bighead carp (4.2 to 5.5 g/day) followed by silver carp (3.3 to 5.0 g/day), common carp (0.2 to 0.3 g/day), and grass carp (0.12 to 0.15 g/day). Survival rate was highest in bighead (82 to 100%) and lowest in grass carp (20 to 27%).

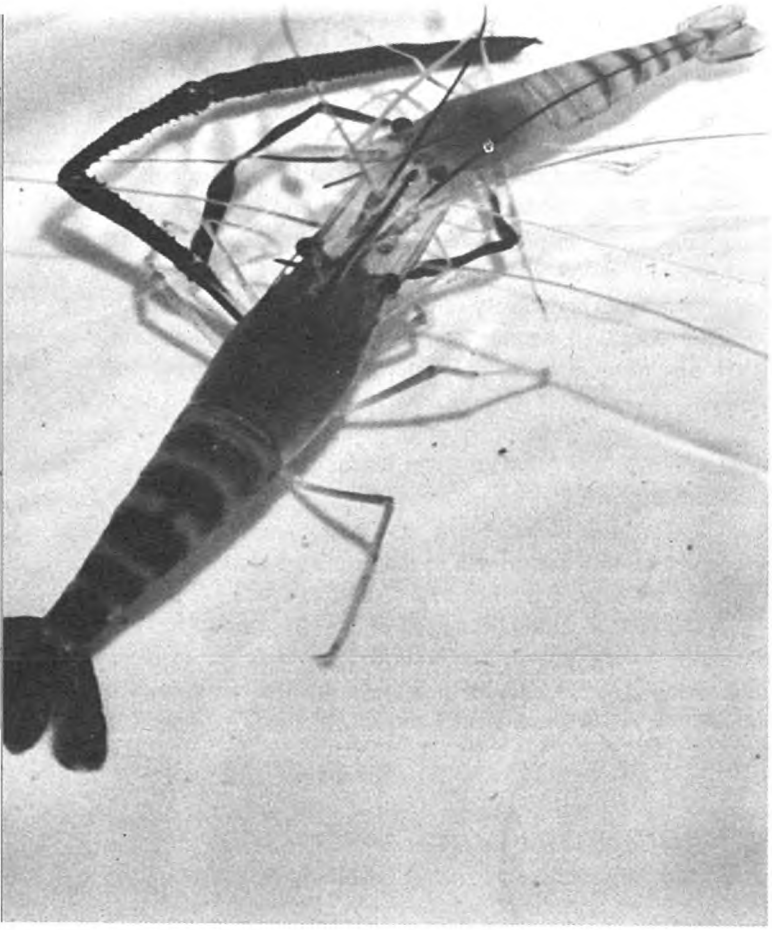
Average net production of all species in polyculture ranged from 6.76 to 8.69 kg/cu m or 67 to 86 tons/ha.

2. **Polyculture of milkfish, carps, and tilapia in pens in Laguna de Bay.** The feasibility of increasing fish production using polyculture in pens was demonstrated. The average total net production of 25.6 tons/ha (1,278.8 kg/pen) was obtained at a stocking density of 66,000 fish/ha and at a ratio of 50 silver carp: 10 tilapia: 1 bighead carp: 5 common carp. Total net production of 11.1 tons/ha (558.1 kg/pen) was obtained at a ratio of 45 milkfish: 15 tilapia: 1 bighead carp: 5 common carp. Production of silver carp as primary species in polyculture was 2 to 2.5 times higher than milkfish at the same stocking ratio.

Addition of bighead carp, tilapia, and common carp did not interfere with the growth of the primary species, instead it increased production by 9 to 11% (1 to 2 tons/ha).

The total stocking density of 66,000 fish/ha was far from optimum during the culture period (May-October 1980) as final mean weights and daily growth rates of all species in polyculture did not vary significantly.

Harvesting *Tilapia* fingerlings.



Freshwater prawn (*Macrobrachium rosenbergii*).

Carp, *Cyprinus carpio*.

Macrobrachium sp. Larval Rearing

Preliminary observations on the larval morphology of *Macrobrachium* sp. from Bulacan revealed 8 distinct larval stages which were completed in 41 days. Based on the monitored data, salinity was 12 parts per thousand; pH, 7.9 to 8.6; temperature, 25 to 28°C and nitrite, 10 to 65 parts per billion.

The first successful larval rearing of *Macrobrachium rosenbergii* was in December, 1979. Temporary enclosures to minimize temperature fluctuation were used. Larvae were reared in a medium with salinity of 12 to 15 parts per thousand; pH of 7.9 to 8.5; temperature, 28 to 31°C; total hardness of 14 to 60 mg/liter $CaCO_3$. Thirty larvae metamorphosed into postlarvae in 29 days using heated water.

Limnology

Comparative study of an open area and a fish pen using the polyculture system. Physico-chemical and biological parameters in the open waters of Laguna de Bay and in an experimental fishpen and immediate environs were monitored.

Available data show distinct relationships between lake behavior and fish growth and production. The removal of abiogenic turbidity by the saline water in summer stimulated plankton production and gave the fishes in the experimental cages and pens their highest average weight increments. After August, however, plankton production dropped to about 50% of summer levels.

Gut content analyses of fishes grown in polyculture showed presence of both phytoplankton and zooplankton. No selectivity for phytoplankton species was noted. However, bighead and common carp showed stronger preference for copepods despite the higher number of rotifers in their diet.

SEAFDEC Institute of Aquaculture

Training & Extension

Three hundred eighty-seven people having varied interests in aquaculture participated in the training programs of the Department in 1980. They came from 13 countries including the Philippines.

Four short-term training courses for international participants were offered. These were attended by 70 trainees from 11 countries: Philippines (21), Malaysia (26), Thailand (12), Nigeria (2), and Fiji, Indonesia, India, Sudan, Saudi Arabia, Tanzania, and Western Samoa (1 each).

Three local training programs were offered, and attended by a total of 187 participants from all regions of the Philippines.

The Department, in cooperation with the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), launched the Aquabusiness Project Development and Management (APDEM) Workshop in 1980. The first APDEM workshop was conducted from February 16 to March 14 in Tigbauan, Iloilo. Thirty-two Filipinos, and one each from the Republic of Kiribati, Hongkong, and Nigeria, participated in the workshop.

The second APDEM course (July 28–August 16), held at the University of the Philippines College of Business Administration in Quezon City, attracted 53 participants from the Philippines and one from Nigeria. The third APDEM workshop, held from November 19 to December 11 in Tigbauan, Iloilo, had 41 participants: 29 from the Philippines, 5 from Malaysia, 3 from Nigeria, and one each from Singapore, Guam, Taiwan, and Indonesia. A total of 130 participants having different aquaculture-related interests, diverse educational and work backgrounds, and representing different sectors of the aquaculture industry, attended the three APDEM courses.

International trainees observe *P. monodon* juveniles in a recirculating 1.2-ton nursery fiberglass tank. The biomechanical filter consisting of algae and graded sand can be seen to the right.

About 130 participants attended the three APDEM courses held in 1980 while 257 trainees completed courses offered under the international and national training programs of the Department.

SUMMARY OF TRAINING PROGRAMS OFFERED IN 1980

Course	Duration	Number of participants
A. INTERNATIONAL TRAINING PROGRAMS		
Aquaculture Research Methodology	April 7 – August 7	14
Aquaculture Management – Milkfish	May 5 – July 5	11
Aquaculture Management – Prawn	August 25 – October 24	24
Small-Scale Prawn Hatchery Management	October 13 – November 21	21
	Sub-Total	70
B. NATIONAL TRAINING PROGRAMS		
Prawn Culture	April 14–19	15
Small-Scale Prawn Hatchery Management	October 13 – November 12	10
On-site Training:		
Aklan	June 27 – July 1	51
Roxas City	October 3 –5	57
Bataan	December 12–14	54
	Sub-Total	187
C. APDEM WORKSHOPS		
APDEM I	February 16 – March 14	35
APDEM II	July 28 – August 16	54
APDEM III	November 19 – December 11	41
	Sub-Total	130
	TOTAL	387

During the year, 137 fishery students from various institutions throughout the country enrolled for off-campus training in the Department. This training involves 200 hours for B.S. Fisheries Education students, and 400 hours for B.S. Fisheries students, as part of the requirements for graduation. This activity has been undertaken by the Department since 1975.

School	No. of trainees
Southern Ilocos Polytechnic State College, Sto. Tomas, La Union	31
Central Luzon State University, College of Fisheries, Muñoz, Nueva Ecija	13
University of the Philippines, College of Fisheries, Diliman, Q.C.	8
University of Sto. Tomas, Manila	1
Bicol University, College of Fisheries, Tabaco, Albay	2
Tario Lim Memorial School of Fisheries, Tibiao, Antique	10
Iloilo State College of Fisheries, Barotac Nuevo, Iloilo	45
Central Philippine University, Iloilo City	3
Negros Occidental School of Fisheries, Binalbagan, Negros Occidental	5
Bohol School of Fisheries, Candijay, Bohol	5
Moalboal School of Fisheries, Moalboal, Cebu	5
Samar Regional Institute of Fisheries Technology, Catbalogan, Samar	1
Xavier University, Cagayan de Oro City	1
Mindanao State University, College of Fisheries, Marawi City	2
Mindanao Regional School of Fisheries, Zamboanga City	5
TOTAL	137

Communications & Publications

The Department continuously strengthened its technology dissemination program through the Communications/ Publications Unit. More information materials were produced and distributed, as technology generated by the Department continued to gain interest all over the world. The Unit also provided back-up services to the research, training, and administrative activities of the Department. These services include printing, photography, audio-visual, and art services.

During the year, the *Fish Farming Handbook* was published. The 300-page handbook served as a source of information for aquaculture technicians and fishfarmers.

The following extension manuals were revised and reprinted: 1) *Mussel Farming* by Wilfredo Yap, Adam Young, Celia Orano, and Teresa de Castro; 2) *Broodstock of Sugpo (Penaeus monodon) and other Penaeid Prawns* by Jurgenne Primavera; 3) *Manual on Prawn Culture* by W. Yap, Florentino Apud, and J. Primavera; 4) *Milkfish Culture in Brackishwater Ponds* by Melchor Lijauco, Jesus Juario, Dan Baliao, Eliseo Griño and Gerald Quinitio; 5) *Nutrition and Feeding of Penaeus monodon* by Felicitas Pascual; 6) *Manual of Operations: Sugpo Pond Culture* by J. Primavera and F. Apud; and 7) *Design, Operation and Economics of a Small-Scale Hatchery for Larval Rearing of Sugpo* by Rolando Platon.

Three technical reports were published: 1) *Traditional Devices and Gear for Collecting Fry of "Sugpo" Giant Tiger Prawn, Penaeus monodon in the Philippines* by Hiroshi Motoh; 2) *Fishing Gear for Prawn and Shrimp Used in the Philippines Today* by H. Motoh; and *A Study on the Milkfish Fry Fishing Gears in Panay Island, Philippines* by Shigeru Kumagai, Teodora Bagarinao and Abdul Unggui.

Four issues of the *Quarterly Research Report* were printed. The reports contain extended abstracts of the results of studies undertaken by the Department.

The Unit also compiled and prepared for publication the Annual Report of the Department for the year 1979.

Asian Aquaculture, the Department's monthly newsletter, reached 1,800 institutions and individuals in 84 countries. It features research and industry development information from various sources in the world.

The fortnightly *Fish Farm News* caters to fishfarmers in the Philippines. Some 700 subscribers received copies of the *Fish Farm News* which contains at least 10 farming tips per issue.

During the year, the Unit also produced Report No. 3 of the *Popular Aquaculture Report Series* entitled: "What's in Store for the Country's Prawn Hatcheries", which was published in *Greenfields,* December 1980, and *Farming Today,* October 1980.

Aside from the Philippine-based mass media institutions, a good number of well-known international magazines on aquaculture and fisheries used the articles published by the news services of the Department, among them: *Australian Fisheries, Fish Farming International* (England), *Aquaculture Magazine* (U.S.A.), *Fishing News International* (England), and *Aquaculture Digest* (U.S.A.).

Scientific Information

The Library-Documentation Unit of SIA continued building up the Department's information bank while at the same time expanding its outreach program.

Library Services

The activities of the Library centered on increasing its collection, and actively disseminating the collected information to the research staff of the Department.

There are at present 7,428 volumes of books, monographs, technical reports and pamphlets, 310 microfiche titles and 6 reels of microfilm, 1,386 bound journals and annual reports, and 4,343 reprints in the library collection.

Monthly issues of *Acquisitions List* were prepared and sent to the research staff of the Department. The 1979 annual cumulation of *The Catalog of the Library* was issued during the year.

The *Serial Holdings of the SEAFDEC Aquaculture Department Library* is being prepared for publication.

Gifts and exchange arrangements with about 225 aquaculture and fisheries research and educational institutions were firmed up. Of the number of exchange partners, 150 are foreign and 75 are local.

Selective Dissemination of Information (SDI) was envisioned to support the information needs of the research staff of the Department. It was addressed initially to 14 project leaders/supervisors of the Tigbauan Station. Current journal issues were scanned and articles which appeared to be of interest to the project leaders/supervisors were brought to their attention. During the year, 452 articles (1,292 pages) were sent to project leaders/supervisors. The Binangonan and Leganes staff will be included in the SDI next year.

The Aquaculture Scientific Literature Service (ASLS) is addressed to aquaculture scientists, research organizations, schools, and development workers throughout the country. The ASLS aims to augment the information requirements of the recipients and bring the latest state-of-the-art information to them.

Twenty-nine aquaculture scientists, research organizations, schools, and development workers have earlier benefited from this service. Some 50 more scientists and organizations were invited to enroll in the service at a subsidized cost. A total of 1,135 articles (15,346 pages) were sent to ASLS enrollees during the year.

Documentation Services

Initiated in early 1979, the Aquaculture Documentation (AQUADOC) Project lists, photocopies, and acquires relevant aquaculture materials available in the library collections of aquaculture/fisheries institutions, research organizations, and development workers in the Philippines. In addition to a survey of various aquaculture libraries throughout the country, AQUADOC also established linkages with other library/information centers.

Selection and acquisition of materials for documentation was based on recency and relevance of information on culture and biology of tropical fish species, and Asian R & D activities in aquaculture fisheries.

As of October 1980, fifty institutions have been surveyed: 29 universities and schools offering fisheries as part of their curricula; 16 government entities; and 5 private and/or international institutions.

Aquaculture Abstracts was compiled and published on a quarterly basis for dissemination to scientists and development workers. Relevant tropical aquaculture materials found in the Library were abstracted, published and distributed. A total of 1,680 abstracts were compiled and published in the following issues of *Aquaculture Abstracts:*

Aquaculture Abstracts, 1979	**No. of titles**
Part II Vertebrates:	
Carp	101
Catfish, Mullet, Tilapia	167
Fishes (in General)	203
Fishes (Other Species)	146
Part III Aquatic Plants: Algae	150
Aquaculture Abstracts, 1980	
First Quarter	350
Second Quarter	293
Third Quarter	270

Technology Verification & Packaging

The TVP Unit was reactivated in May 1980. After consultation with researchers and private fishfarm operators, 18 projects were drawn up for eventual development and implementation.

After careful deliberation of the TVP concepts this year, methodologies for on-farm and in-country testing programs were articulated in a TVP plan document entitled "Technology Verification: A Program for Catalyzing Aquaculture Opportunities and Support."

Publications and Seminars

Publications

The following papers were contributed to various national and international journals and/or presented at conferences:

PAPERS IN 1980

Buri, P., 1980. Ecology on the feeding of milkfish fry and juveniles *Chanos chanos* (Forsskal). Memoirs. Kagoshima Univ. Res. Center S. Pac., 1:25-42.

Buri, P. and Motoh, H., 1980. The skull of milkfish *Chanos chanos* Forsskal. Proc. Jap. Soc. Syst. Ecol., 19:45-52.

Coloso, R.M., 1980. Preliminary studies in some aspects of amino acid biosynthesis in juveniles of *Penaeus monodon* Fabricius. Paper presented at the Annual Convention of the Philippine Biochemical Society, Manila, Philippines, December, 1980.

De los Santos, C., Jr., Sorgeloos, P., Laviña E. and Bernardino, A., 1980. Successful inoculation of *Artemia* and pond production of cysts in man-made salterns in the Philippines. In: The brine shrimp *Artemia,* Vol. 3. Ecology, Culturing, Use in Aquaculture. G. Persoone, P. Sorgeloos, O. Roels and E. Jaspers (eds.). Universa Press, Wetteren, Belgium, pp. 159-163.

Hatai, K., Bian, B.Z., Baticados, M.C.L. and Egusa, S., 1980. Studies on the fungal diseases in Crustaceans. II. *Haliphthoros philippinensis* sp. nov. isolated from cultivated larvae of the jumbo tiger prawn *(Penaeus monodon).* Trans. Mycol. Soc. Jap., 21:47-55.

Juario, J.V., 1980. Induced breeding of saltwater finfish in the Philippines. Paper presented at the IDRC Induced Fish Breeding Symposium-Workshop, Singapore, 25-28 November 1980.

Kawamura, G. and Bagarinao, T., 1980. Fishing methods and gears in Panay Island, Philippines. Memoirs. Fac. Fish. Kagoshima Univ., 29:81-121.

Kawamura, G. and Hara, S., 1980. On the visual feeding of milkfish larvae and juveniles in captivity. Bull. Jap. Soc. Sci. Fish., 46: 1297-1300.

Kawamura, G. and Hara, S., 1980. The optomotor reaction of milkfish larvae and juveniles. Bull. Jap. Soc. Sci. Fish., 46:929-932.

Kawamura, G., Hara, S. and Bagarinao, T., 1980. Fundamental study on behavior of milkfish fry for improvement of the traditional fry collecting gears in the Philippines. Memoirs. Kagoshima Univ. Res. Center S. Pac., 1:65-74.

Kumagai, S. and Castillo, N., 1980. Changes in length and weight of milkfish *Chanos chanos* larvae preserved in formalin. Fish. Res. J. Philipp., 5:17-33.

Marte, C.L., 1980. The food and feeding habits of *Penaeus monodon* Fabricius collected from Makato River, Aklan, Philippines (Decapoda, Natantia). Crustaceana, 38: 225-236.

Motoh, H. and Buri, P., 1980. Development of the external genitalia of the giant tiger prawn, *Penaeus monodon.* Bull. Jap. Soc. Sci. Fish., 46:149-155.

Motoh, H. and Buri, P., 1980. Early post mysis stages of the giant tiger prawn, *Penaeus monodon* Fabricius. Researches on Crustacea, No. 10 Carcin. Soc. Japan, pp. 13-34.

Pantastico, J. and Oliveros, E.N., 1980. Acclimation of *Penaeus monodon* postlarvae to freshwater. Fish. Res. J. Philipp., 5:33-38.

Primavera, J.H., 1980. Studies on broodstock of sugpo *Penaeus monodon* Fabricius and other penaeids at SEAFDEC Aquaculture Department. Paper presented at the Intl. Symposium on Coastal Aquaculture, Cochin, India, 12-18 January 1980.

Primavera, J., Acosta, P. and Estenor, D., 1980. Preliminary trials of combined *Artemia* rearing and salt production in earthen salt ponds in the Philippines. In: The brine shrimp *Artemia,* Vol. 3. Ecology, Culturing, Use in Aquaculture. G. Persoone, P. Sorgeloos, O. Roels and E. Jaspers (eds.). Universa Press, Wetteren, Belgium, pp. 205-214.

Primavera, J.H., Young, T. and de los Reyes, C., 1980. Survival, maturation, fecundity and hatching rates of ablated and unablated *Penaeus indicus* H.M. Edwards from brackishwater earthen ponds. Paper presented at the Intl. Symposium on Coastal Aquaculture, Cochin, India, 12-18 January 1980.

Pudadera, R., Primavera, J.H., and Young, T., 1980. Effects of different sex ratios on maturation, fecundity and hatching rates of ablated *Penaeus monodon* wild stock. Fish. Res. J. Philipp., 5:1-6.

Santiago, A., Jr., 1980. Review of induced breeding of freshwater fishes of the Philippines. Paper presented at the IDRC Induced Breeding Symposium-Workshop, Singapore, 25-28 November 1980.

Senta, T., Kumagai, S. and Castillo, N., 1980. Occurrence of milkfish *Chanos chanos* (Forsskal) eggs around Panay Island, Philippines. Bull. Fac. Fish. Nagasaki Univ., 48:1-11.

Sorgeloos, P., Baeza-Mesa, M., Bossuyt, E., Bruggeman, E., Dobbeleir, J., Versichelle, D., Laviña, E., and Bernardino, A., 1980. The culture of *Artemia* on rice bran: The conversion of a waste-product into highly nutritive animal protein. Aquaculture, 21:393-396.

Tan, R. and de Mesa, I., 1980. A statistical index of growth condition in aquaculture experiment. Paper presented at the Second National Convention on Statistics, Manila, 2-3 December 1980.

Villegas, C. and Kanazawa, A., 1980. Rearing of the larval stages of prawn, *Penaeus japonicus* Bate, using artificial diet. Memoirs. Kagoshima Univ. Res. Center S. Pac., 1:43-49.

Villegas, C., Ti, T., and Kanazawa, A., 1980. The effects of feeds and feeding levels on the survival of a prawn, *Penaeus monodon* larvae. Memoirs. Kagoshima Univ. Res. Center S. Pac., 1:51-55.

Young, A., 1980. Larval and postlarval development of the windowpane shell *Placuna placenta* L. (Bivalvia: Placunidae) with a discussion on its natural settlement. Veliger, 23: 141-148.

IN PRESS

Buri, P., Bañada, V., and Triño, A., Developmental and ecological stages in the life history of milkfish. Fish. Res. J. Philipp.

Kawamura, G. and Castillo, A. A new device for recording the feeding activity of milkfish. Bull. Jap. Soc. Sci. Fish.

Lio-Po, G., Sanvictores, R., Baticados, M.C. and Lavilla, C. *In vitro* effects of fungicides on *Lagenidium* sp. isolated from *Penaeus monodon* larvae and *Scylla serrata* eggs. J. Fish Diseases.

Motoh, H. Diel fluctuations in catch of the post-larval green tiger prawn *Penaeus semisulcatus* in the Philippines. Bull. Jap. Soc. Sci.

Motoh, H. and Buri, P. Identification of the postlarvae of the genus *Penaeus* appearing at the shore waters. Bull. Jap. Soc. Sci. Fish.

Motoh, H. and Buri, P. Study on penaeids in the Philippines. Researches in Crustacea, Carcin. Soc. Japan.

Motoh, H., Solis, N., Caligdong, E. and Boblo, F. Abundance of the giant tiger prawn, *Penaeus monodon* caught with fish corrals in the Philippines. Bull. Jap. Soc. Sci. Fish.

Motoh, H., Solis, N. and Gelangre, M. Abundance of postlarvae of the genus *Penaeus* appearing along shorewaters of Southern Panay Island, Philippines. Bull. Jap. Soc. Sci. Fish.

Motoh, H., Solis, N. and Gelangre, M. Diel fluctuations in catch of the postlarval giant tiger prawn *Penaeus monodon* in the Philippines. Bull. Jap. Soc. Sci. Fish.

Motoh, H., Solis, N. and Caligdong, E. Relations between size, sexual maturity and fecundity of the giant tiger prawn, *Penaeus monodon* Fabricius. Bull. Jap. Soc. Sci. Fish.

Pudadera, R., Primavera, J.H. and Borlongan, E. Effect of substrate types on fecundity and nauplii production of ablated *Penaeus monodon* Fabricius. Philipp. J. Sci.

PUBLISHED IN 1976

Chaudhuri, H., Juario J., Samson, R. and Tiro, L., 1976. Notes on the external sex characters of *Chanos chanos* (Forsskal) spawners. Fish. Res. J. Philipp., 1:76-80.

Motoh, H., 1976. Larvae of decapod crustacea of the Philippines II. Laboratory-hatched first zoea of box crab. Phil. Agric., 60:345-349.

Motoh, H. and Villaluz, A., 1976. Larvae of decapod crustacea of the Philippines – I. The zoeal stages of a swimming crab, *Charybdis cruciata* (Herbst) reared in the laboratory. Bull. Jap. Soc. Sci. Fish., 42:523-531.

Primavera, J.H., 1976. Survival rates of different *Penaeus monodon* Fabricius postlarval stages. Philipp. J. Sci., 105:193-203.

Primavera, J.H., Apud, F. and Usigan, C., 1976. Effect of different stocking densities on survival and growth of sugpo, *(Penaeus monodon* Fabricius) in a milkfish-rearing pond. Philipp. J. Sci., 105: 193-203.

Rodriguez, L.M., 1976. A simple method of tagging prawns. U.P. Natural and Applied Sci. Bull., 28:303-308.

PUBLISHED IN 1977

Chaudhuri, H. and Juario, J.V., 1977. Use of hormone in breeding warm-water fishes with special reference to milkfish, *Chanos chanos* (Forsskal). Aquaculture, 13: 95-113.

Gacutan, R.Q., and Llobrera, A.T., 1977. Effect of furanace on the zoea and mysis of *Penaeus monodon.* Kalikasan, Philipp. J. Biol. 6:263-268.

Gacutan, R.Q., Llobrera, A. and Baticados, M.C., 1977. Effects of furanace on the development of larval stages of *Penaeus monodon* Fabricius. Proc. 2nd Biennial Crustacean Health Workshop, Galveston, Texas.

Gacutan, R.Q., Llobrera, A., Santiago, C., Gutierrez, P., and Lio-Po, G., 1977. A suctorean parasite of *Penaeus monodon* larvae. Proc. 2nd Biennial Crustacean Health Workshop, Galveston, Texas.

Primavera, J.H. and Apud, F., 1977. Pond culture of sugpo, *Penaeus monodon* (Fabricius). Philipp. J. Fish., 14: 160-190.

Santiago, A., Jr., 1977. Successful spawning of cultured *Penaeus monodon* Fabricius after eyestalk ablation. Aquaculture, 11:185-196.

Senta, T. and Kumagai, S., 1977. Variation in the vertebral number of the milkfish *Chanos chanos* collected from various localities. Bull. Fac. Fish., Nagasaki Univ., 43: 35-40.

Sorgeloos, P., Bossuyt, E., Laviña, E., Baeza-Mesa, M. and Persoone, G., 1977. Decapsulation of *Artemia* cysts: a simple technique for the improvement of the use of brine shrimp in aquaculture. Aquaculture, 12:311-315.

Yap, W.G., 1977. Cultivation of live feed for the rearing of sugpo *(Penaeus monodon)* larvae. In: E. Styczynska-Jurewicz, *et al.* (eds.). Cultivation of fish fry and its live food. European Mariculture Society Spec. Pub. No. 4, 546 p.

PUBLISHED IN 1978

Laviña, E.M., 1978. A study on certain aspects of the biology and control of *Caligus* sp., and ectoparasite of the adult milkfish *Chanos chanos* (Forsskal). Fish. Res. J. Philipp. 3:11-24.

Lio-Po, G., Lavilla, C.R. and Llobrera, A.T., 1978. Toxicity of malachite green to the larvae of *Penaeus monodon.* Kalikasan, Philipp. J. Biol., 7:238-246.

Primavera, J.H., 1978. Induced maturation and spawning in five-month old *Penaeus monodon* Fabricius by eyestalk ablation. Aquaculture, 13:355-359.

Primavera, J.H. and Borlongan, E., 1978. Ovarian rematuration of ablated sugpo prawn *Penaeus monodon* Fabricius. Ann. Biol. Anim. Bioch. Biophys., 18:1067-1072.

Primavera, J.H., Borlongan, E. and Posadas, R., 1978. Mass Production in concrete tanks of sugpo, *Penaeus monodon* spawners by eyestalk ablation. Fish. Res. J. Philipp., 3:1-12.

Tolosa, R.T., 1978. Notes on the construction of a 12 cu m ferrocement tank for prawn broodstock. J. Ferrocement, 8:93-103.

Yap, W.G., 1978. Settlement preference of the brown mussel *Modiolus metcalfei* Hanley and its implications on the aquaculture potential of the species. Fish. Res. J. Philipp., 3:65-70.

PUBLISHED IN 1979

Apud, F., Yap, W.G. and Gonzales, K., 1979. Mass production of *Penaeus monodon* Fabricius juveniles in earthen nursery ponds. Presented at the Tenth World Mariculture Society Meeting, Hawaii, Jan. 26-30, 1979.

Bian, B.Z., Hatai, K., Po, G.L. and Egusa, S., 1979. Studies on the fungal diseases in Crustaceans. I. *Lagenidium scyllae* sp. nov. isolated from cultivated ova and larvae of the mangrove crab *(Scylla serrata).* Trans. Mycol. Soc. Jap. 20:115-124.

Chaudhuri, H., 1979. Status and problems of carp hatchery and management. PCARR Symposium-Workshop on Fish Hatchery/Nursery Development and Management, Metro Manila, Sept. 27-29, 1979.

Gacutan, R.Q. and Baticados, M.C.L., 1979. Notes on *Lagenidium* from larvae of *Penaeus monodon* Fabricius. I. Isolation and Culture in artificial media. Fish. Res. J. Philipp., 4:24-28.

Juario, J., 1979. Status and problems of milkfish propagation. PCARR Symposium-Workshop on Fish Hatchery/Nursery Development and Management, Metro Manila, Sept. 27-29, 1979.

Kumagai, S. and Bagarinao, T., 1979. Results of drift card experiments and considerations on the movement of milkfish eggs and larvae in the Northern Sulu Sea. Fish. Res. J. Philipp., 4:64-81.

Liao, I.C., Juario, J.V., Kumagai, S., Nakajima, H., Natividad, M. and Buri, P., 1979. Induced spawning and larval rearing of milkfish *Chanos chanos* (Forsskal). Aquaculture, 18:75-93.

Lim, C. and Destajo, W.H., 1979. Effects of crude, semi-purified and purified starch of sago *(Metroxylon sagu* Rottb.) on the water stability of pelleted shrimp diets. Fish. Res. J. Philipp., 4:19-23.

Lim, C., Sukhawongs, S. and Pascual, F.P., 1979. A preliminary study on the protein requirements of *Chanos chanos* (Forsskal) fry in a controlled environment. Aquaculture, 17:195-201.

Lim, C., Suraniranat, P. and Platon, R., 1979. Effect of various protein sources on the growth and survival of *Penaeus monodon* larvae. Kalikasan, Philipp. J. Biol., 8:29-36.

Madamba, J.C., 1979. Subsistence aquaculture and technology transfer among developed and developing countries. Proc. World Maricul. Soc., 10:182-193.

Motoh, H., 1979. Larvae of decapod crustacea of the Philippines. III. Larval development of the giant tiger prawn, *Penaeus monodon* reared in the laboratory. Bull. Jap. Soc. Sci. Fish., 45:1201-1216.

Motoh, H., and Buri, P., 1979. Larvae of decapod crustacea of the Philippines. IV. Larval development of the banana prawn *Penaeus merguiensis* reared in the laboratory. Bull. Jap. Soc. Sci. Fish., 45:1217-1235.

Motoh, H. and Muthu, M.,1979. On a new species of *Metapenaeus* (Crustacea, Decapoda: Penaeidae) from the Philippines. Bull. Jap. Soc. Sci. Fish., 45: 1351-1354.

Muthu, M. and Motoh, H., 1979. On a new species of *Trachypenaeus* (Crustacea, Decapoda: Penaeidae) from the Philippines with notes on related species. Researches in Crustacea, Carcin. Soc. Japan, 9:57-63.

Muthu, M. and Motoh, H., 1979. On a new species of *Penaeus* (Crustacea, Decapoda: Penaeidae) from North Borneo. Researches in Crustacea, Carcin. Soc. Japan, 9:64-70.

Pantastico, J.B. and Baldia, J., 1979. Supplemental feeding of *Tilapia mossambica.* Proc. World Symp. on Finfish Nutrition and Fishfeed Technology, Hamburg, Germany, June 20-23, 1978.

Pascual, F.P. and Destajo, W.H., 1979. Growth and survival of *Penaeus monodon* postlarvae fed shrimp head meal and fish meal as primary animal sources of protein. Fish. Res. J. Philipp., 4:29-36.

Primavera, J.H., 1979. Notes on the courtship and mating behavior in *Penaeus monodon* Fabricius (Decapoda, Natantia). Crustaceana, 37: 387-392.

Primavera, J.H., Lim, C. and Borlongan, E., 1979. Effect of different feeding regimes on reproduction and survival of ablated *Penaeus monodon* Fabricius. Kalikasan, Philipp. J. Biol., 8:227-235.

Primavera, J.H. and Yap, W.G., 1979. Status and problems of broodstock and hatchery management of sugpo, *Penaeus monodon* and other penaeids. PCARR Symposium-Workshop on Fish Hatchery/Nursery Development and Management, Metro Manila, Sept. 27-29, 1979.

Primavera, J.H., Lim, C. and Borlongan, E., 1979. Feeding regimes in relation to reproduction and survival of ablated *Penaeus monodon.* Kalikasan, Philipp. J. Biol., 2:227-235.

Villegas, C.T., 1979. Preliminary studies on growth and survival of *Penaeus japonicus* postlarvae fed with *Tapes philippinarum* and commercial formula feed. Fish. Res. J. Philipp., 3:39-43.

Villegas, C.T. and Kanazawa, A., 1979. Relationship between diet composition and growth rate of the zoeal and mysis stages of *Penaeus japonicus* Bate. Fish. Res. J. Philipp., 4:32-40.

Seminars

The following research seminars were conducted by Department research staff, and visiting experts and scientists, at the Tigbauan Research Station:

Date	Topic	Speaker
January 18	Brackishwater Farming in Pradesh, India	D.V. Reddi
January 25	Studies in AQUACOP	Denis Coatanea
February 4	Studies in AQUACOP	Philip Hatt
February 7	Studies on Broodstock of Sugpo *Penaeus monodon* Fabricius and other Penaeids at the SEAFDEC Aquaculture Department	Jurgenne Primavera
	Survival, Maturation, Fecundity, and Hatching Rates of Unablated and Ablated *Penaeus indicus* H.M. Edwards from Brackishwater Ponds	

February 14	Diel Fluctuations in Catch of the Postlarval Giant Tiger Prawn, *Penaeus monodon*	Hiroshi Motoh
	Identification of the Postlarval *Penaeus* (Decapoda, Penaeidae) Appearing Along Shorewaters	Noel Solis
February 21	Aquaculture Experiments in Boreal Conditions – Experiments in Kiel Fjord	Holger Grave
February 26	Observation Tour of Prawn and Finfish Propagation in Thailand, Singapore, and India	Shiro Hara Jurgenne Primavera
March 6	An Evaluation Study of the First Two years of the SEAFDEC Cooperators' Program	Rosita Tenedero
March 13	Study of the Scientific Information Needs and Literature Use of Researchers at the Aquaculture Department, SEAFDEC	Rebecca Orejana
March 20	Aquaculture Engineering Experiments at the Tokyo University of Fisheries	Pastor L. Torres, Jr.
March 27	Feedback System Culture of *Brachionus plicatilis* Muller	Porfirio P. Gabasa, Jr.
April 10	Successful Inoculation of *Artemia* and Production of Cysts in Man-made Salterns in the Philippines	Ceferino delos Santos, Jr.
April 17	The Fishery and Utilization of the Windowpane-Oyster, *Placuna placenta*	Wilfredo G. Yap
April 24	Biochemical and Biological Analyses of Geographical Strains of *Artemia*	Kenneth L. Simpson
May 22	Preliminary Studies in Some Aspects of Amino Acid Biosynthesis in Juveniles of *Penaeus monodon* Fab.	Relicardo M. Coloso
June 5	Growth and Survival of Milkfish (*Chanos chanos* Forsskal) and Prawn (*Penaeus monodon* Fabricius) in a Polyculture System	Beato Pudadera, Jr.
June 19	The Effect of Various Salinity Levels and Stocking Density Manipulation Methods on the Survival of Milkfish Fry (*Chanos chanos* Forsskal) During Storage	Gerald Quinitio
June 26	Growth, Survival and Macronutrient Composition of *Penaeus monodon* Fabricius Larvae Fed with *Tetraselmis chuii* and *Chaetoceros calcitrans*	Emilia Quinitio
July 10	Mass Production of Juvenile Crabs in Japan	Lynda Cowan
July 17	Genetic Deterioration, Upgrading and Management of a Wild Common Carp (*Cyprinus carpio*) Population: A Computer Simulation Study	Randolf Yamada

July 24	The Effects of Densities of Two Food Organisms on the Rates of Survival and Development of *Penaeus monodon* Fabricius	Isidra Bombeo
July 31	The Potential Use of Cane Sugar Processing Wastewater for Tilapia Culture	Candelaria Casalmir
August 7	Studies on the Carbohydrases in the Digestive Tract of *Chanos chanos* (Forsskal)	Yvonne Chiu
August 21	Induced Spawning of Milkfish Reared in Captivity	Jesus V. Juario
	Milkfish: Maturation and Spawning in Floating Cages	Flor Lacanilao
September 4	Study on the *Nautilus* sp.	Y. Kanie
October 16	Histopathology of Microsporidiosis of White Prawn, *Penaeus merguiensis* de Man	Ma. Cecilia Baticados
October 23	Hormone-Induced Spawning and Embryonic Development of Rabbit fish, *Siganus vermiculatus* (Pisces: Siganidae)	Enrique Avila
October 30	The Influence of Temperature and Salinity on Oxygen Consumption of *Penaeus monodon* Postlarvae	Ma. Suzette dela Rosa
November 6	A Comparative Study of Various Extenders on Milkfish *Chanos chanos* (Forsskal) Sperm Preservation	Shiro Hara
November 13	1. Statistical Analysis of the Condition Factor of Selected Aquaculture Freshwater Species	Imelda de Mesa
	2. A Statistical Index of Growth Condition in Aquaculture Experiment	
November 20	Studies on the Digestive Proteases of Milkfish	Lilian B. Tiro
November 27	The Food and Feeding Habits of Milkfish Fry (*Chanos chanos* Forsskal) Collected from Two Habitats along the Coast of Hamtik, Antique	Jessie Banno
December 4	The Reproductive Cycle of the Green Mussel, *Perna viridis,* in Himamaylan, Negros Occidental	Celia Erlinda Orano

Administration

Japanese ambassador to the Philippines Hideo Tanaka (in bush jacket) is briefed by Aquaculture Department Deputy Chief Kunio Katsutani on the progress of the Department's research programs while Aquaculture Department Chief Rogelio Juliano (in checkered shirt) talks to one of the project leaders.

Major Changes in Administration

Mr. Kunio Katsutani assumed office as Acting Chief of the SEAFDEC Aquaculture Department upon the resignation of Dean Rogelio O. Juliano as Department Chief on September 1, 1980.

Mr. Katsutani joined the Department as Deputy Chief in April 1980 vice Dr. Noboru Hoshino who retired at the age of 66.

AQD Aquaculture Substation

To strengthen regional linkages and cooperation as well as effectively disseminate aquaculture information on research and technology transfer within SEAFDEC member countries, the Aquaculture Department established an aquaculture substation in Changi Point, Singapore in March 1980, on approval of the SEAFDEC Council.

The programs and plans of the substation were developed jointly by AQD, the Changi Aquaculture Unit of the Primary Production Department (PPD) of Singapore and the SEAFDEC Marine Fisheries Research Department (MFRD). MFRD provides the administrative support while PPD provides personnel, physical facilities, maintenance and operating expenditures of the station.

The initial research program of the substation is geared towards mussel research, specifically in areas of post-harvest technology, distribution and marketing of mussels. The Aquaculture Department provided $10,000 for this initial activity.

Other programs envisioned include intensive culture of marine and freshwater finfishes like *Epinephelus, Lates, Lutjanus, Caranx,* and *Ophiocephalus* in cages and tanks. Supportive research projects will concentrate on induced breeding techniques, larval rearing, nutrition and feeds development, engineering of cages and tanks, and fish diseases. Training programs on intensive cage and tank fish culture will also be undertaken.

Organizational Structure

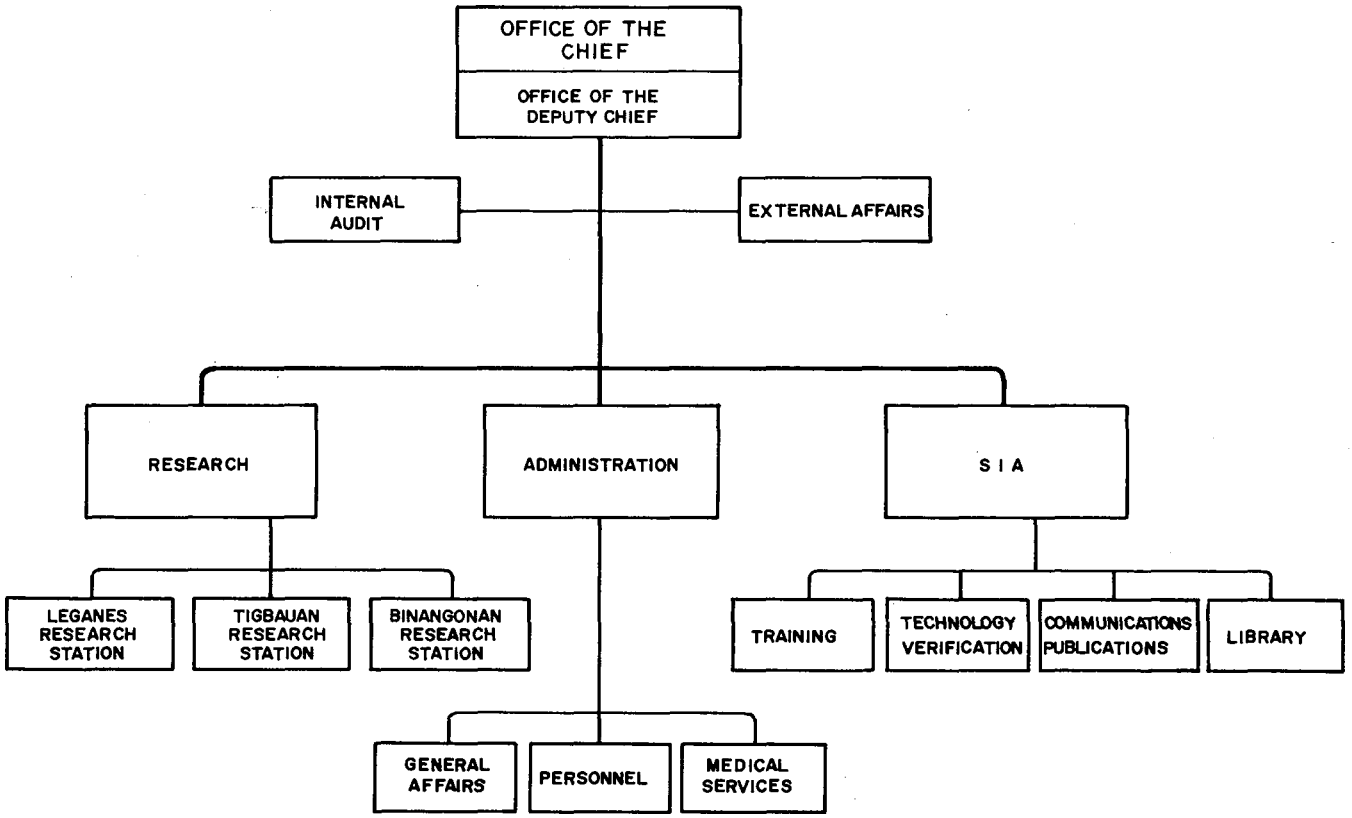
The Department, in 1980, operated three major stations in Tigbauan, Iloilo; Leganes, Iloilo; and Binangonan, Rizal; six substations; and an External Affairs Office in Makati, Metro Manila. The six substations are located in Igang, Guimaras Island; Himamaylan, Negros Occidental; Batan, Aklan; Tacloban, Leyte; Calape, Bohol; and Zamboanga City.

In order to continue existing studies of the aquaculture project at the Zamboanga City Substation, which was partially phased out in March 1980, a Memorandum of Agreement was signed between the Department and the Zamboanga Regional Institute of Fisheries Technology (ZRIFT). Thereafter, ZRIFT took over the Project which aims to: a) speed up the development of fishery and aquatic resources in Western Mindanao through the establishment of pilot demonstration projects and b) conduct research/pilot testing and extension/training programs.

The research projects at the Pandan Milkfish Research Station and Naujan Substation were phased out during the second quarter of 1980.

Operations of the Department were decentralized to enable stations and divisions to institute internal control of their activities. Policies, systems and procedures were formulated and implemented by the various stations and divisions in order to ensure smooth operations supportive of the research thrust of the Department.

ORGANIZATIONAL CHART OF THE AQUACULTURE DEPARTMENT



Personnel Development

The Department had 656 personnel as of December 31, 1980 distributed as follows: Office of the Chief – 31; Office of the Deputy Chief – 2; Tigbauan Research Station – 222; Leganes Research Station – 71; Binangonan Research Station – 74; SEAFDEC Institute of Aquaculture – 38; General Affairs Division – 185; Personnel Management Division (including Medical) – 24; and UP-SEAFDEC Graduate Program – 9.

The research manpower capability of the Department was further enhanced with the completion of graduate studies by 17 of its staff in 1980. Three of them received their degrees from foreign institutions while the rest obtained theirs locally, mostly from the University of the Philippines. The Department is expecting 24 more staff members to finish their doctoral or masteral degrees by 1981-82. The list of graduates follows:

Ph. D.

Alfredo Santiago, Jr., Auburn University (USA), Fisheries and Allied Aquaculture, *Effects of Feeding Shrimp on the Reproductive Performance of Female Channel Catfish in Ponds*

Raul Suarez, University of British Columbia (Canada), Zoology, *Mechanisms of Gluconeogenic Activation in the Rainbow Trout Liver*

Master's Degree

Vicente Bañada, University of the Philippines System (UPS), M.S. Marine Biology, *The Occurrence of Postlarval and Juvenile Stages of Economically Important Fishes in Three Milkfish Fry Collecting Grounds in Panay Island*

Jessie Banno, University of the Philippines in the Visayas (UPV), M.S. Fisheries (Major in Aquaculture), *The Food and Feeding Habits of the Milkfish Fry (***Chanos chanos** *Forsskal) Collected from Two Habitats Along the Coast of Hamtik, Antique*

Ma. Cecilia L. Baticados, UPS, M.S. Biology, *Histopathology of Microsporidiosis of White Prawn,* **Penaeus merguiensis** *de Man, 1888.*

Myrna Bautista, UPS, M.S. Food Science, *Characterization of Lipids and Fatty Acids of Brackishwater and Freshwater Milkfish*

Candelaria Casalmir, UPS, M.S. Environmental Engineering, *The Potential Use of Sugar Waste Water for Tilapia Culture*

Isidra Bombeo, UPV, M.S. Fisheries (Major in Aquaculture), *The Effects of Densities of Two Food Organisms on the Rates of Ingestion, Survival, and Development of* **Penaeus monodon** *from Zoea$_1$ to Postlarva$_1$*

Relicardo Coloso, UPS, M.S. Biochemistry, *Preliminary Studies in Some Aspects of Amino Acid Biosynthesis in Juveniles of* **Penaeus monodon** *Fabricius*

Victoriano Duray, UPV, M.S. Fisheries (Major in Aquaculture), *The Effect of Rice Bran, Fermented Fish Soluble and Cultured Yeast on the Production of an Harpaticoid Copepod,* **Tisbintra elongata** *(Mori, 1942)*

Imelda de Mesa, UPS, Master of Statistics, *Fitting the Bivariate Normal Regression Model When Both Variables are Subject to Measurement Errors with Application in Aquaculture Research*

Beato Pudadera, Jr., UPV, M.S. Fisheries (Major in Aquaculture), *Evaluation of Growth and Survival of Milkfish (***Chanos chanos** *Forsskal) and Prawn (***Penaeus monodon** *Fabricius) in a Polyculture System*

Emilia Quinitio, UPV, M.S. Fisheries (Major in Aquaculture), *The Growth, Survival and Macronutrient Composition of* **Penaeus monodon** *Fabricius Larvae Fed with* **Chaetoceros calcitrans** *and* **Tetraselmis chuii**

Gerald Quinitio, UPV, M.S. Fisheries (Major in Aquaculture), *The Effects of Salinity and Stocking Density Manipulation Method on the Survival of Milkfish Fry,* **Chanos chanos** *Forsskal, during Storage*

Ma. Suzette de la Rosa, UPS, M.S. Zoology, *The Influence of Temperature and Salinity on Oxygen Consumption of* **Penaeus monodon** *postlarvae*

Leonardo Tiro, Jr., University of British Columbia, M.S. in Bio-resource Engineering (Major in Aquaculture), *Culture of the Brine Shrimp,* **Artemia salina** *L. Utilizing* **Dunaliella tertiolecta** *Grown in Swine Waste-Seawater Mixtures and in Defined Inorganic Medium*

Lillian Tiro, UPS, M.S. Marine Biology, *Studies on the Digestive Proteases of Juveniles and Marketable-size Milkfish*

Non-degree Program

During the year, the Department sent 79 staff members to various non-degree training programs, 8 of them abroad.

Personnel Services

Medical Unit

The Medical Unit, through the formulation, adoption and implementation of the Department Medical Policy composed of the Comprehensive Medical Benefit Plan, and the Medical Health and Safety Program, ensured the improvement of working conditions, good health, and proper job motivation of employees. The Medical Policy aims to increase the over-all work efficiency and productiveness of the employees.

During the year, the unit served an average of 950 to 1,000 patients per month or about 50 patients per day. Eighty percent of the patients are Department employees, the rest are dependents.

Under its Community Health and Development Project, the Unit rendered free medical services to about 1,300 residents of Tigbauan, Iloilo and Batan, Aklan. Free medicine, solicited from government and private institutions, was provided to the community. A family planning program was also implemented.

The Unit also initiated sports, recreation, and physical fitness activities which led to the creation of the Sports Development and Recreation Committee.

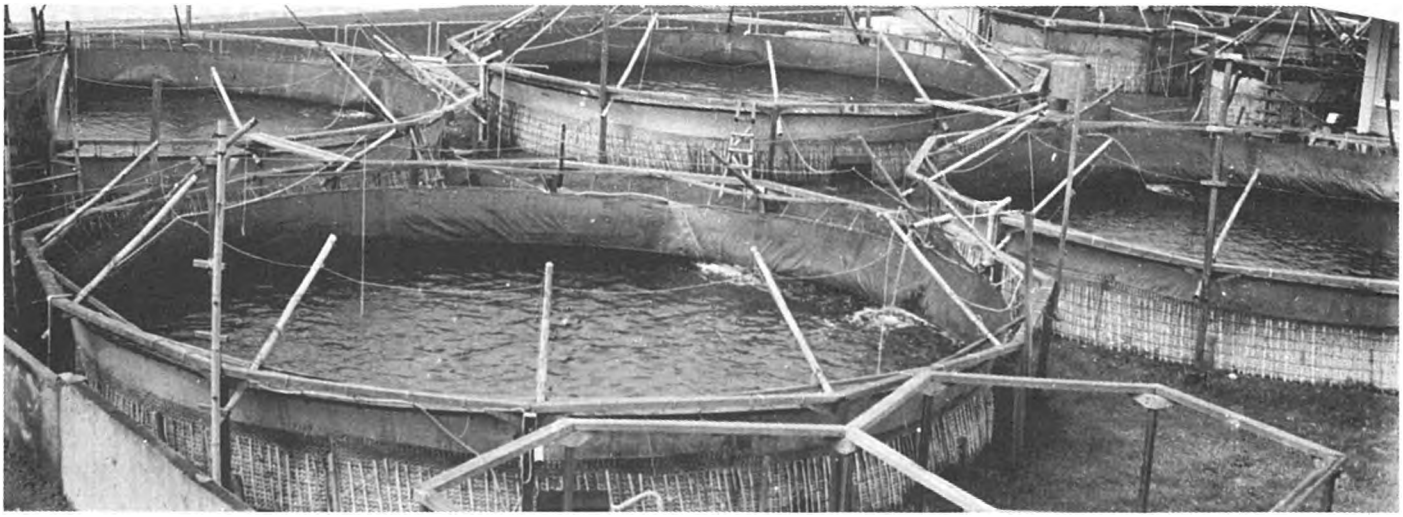
WVSC-SEAFDEC Laboratory School

Some 100 pupils were accommodated in kindergarten, primary, and intermediate non-graded curricula of the Laboratory School, jointly established in 1977 by the Department and the West Visayas State College (WVSC). While the school primarily serves children of Department staff, a significant proportion of the pupils comes from Tigbauan and nearby municipalities.

The curriculum, faculty, and academic standard of the school are supervised by WVSC. On the other hand, the Department provides physical facilities, equipment, operating expenses, as well as salaries and/or honoraria of personnel. These expenses are reflected in an annual budget prepared upon mutual agreement by the WVSC and the Department.

About 1,287 residents of Tigbauan, Iloilo and Batan, Aklan received free medical and dental services from the Aquaculture Department's Medical Unit. This was conducted outside the regular working hours of the medical personnel. Medicine given to the patients were solicited from government and private agencies.

Infrastructure Development



Above: Canvas tanks for milkfish broostock development.
Below: The Scientific Supply House at Tigbauan Research Station.

The major infrastructure development of Tigbauan Research Station included the following:

a. Completion of the Scientific Supply House;
b. Construction and repair of Batan pens and cages;
c. Remodelling of the Pathology Laboratory;
d. Installation of additional canvas tanks and roofing for milkfish broodstock development;
e. Installation of prawn fiberglass nursery tanks at the Wet Lab Extension;
f. Extension of Field Lab for fish hatchery, and construction of green house for larval feed production; and
g. Replacement of cage floats at the Igang Substation.

At the Leganes Research Station, infrastructure development included the following:

a. Construction of three units of 1,000 sq m ponds and guard/pump house for the milkfish maturation experiments;
b. Concreting of gates of 24 units of prawn nursery ponds at the Jalaud area;
c. Construction of an access road to the provincial road; and
d. Installation of electric power lines.

Construction of the necessary infrastructure was resumed at the Binangonan Research Station in order to fully implement its research, training and other activities. Among the research facilities completed were as follows:

a. 18 units of fishpen compartments for carp studies;
b. 36 floating cages with steel drum and bamboo floats for milkfish farming and polyculture with *Penaeus monodon*;
c. 190 units of grow-out cages of varying dimensions for nursery studies;
d. *Macrobrachium* hatchery consisting of glass and wooden aquaria.

A canal was dug across the land bridge of Tapao Point to improve the water movement at the West Cove Area. Two of the four duplex cottages were completed for the use of trainees and Station visitors.

UP-SEAFDEC Graduate Program

The offering of the M.S. Fisheries program major in Aquaculture, a collaboration between the University of the Philippines System (UPS) and the SEAFDEC Aquaculture Department, marked its fourth year of operation on June 7, 1980. The degree program covers a course load totalling 30 units, 24 of which are undertaken during the first two semesters while a thesis project, equivalent to six units, is conducted in the second year. Seventy percent of the program faculty in 1980 were research staff of the Department.

Twenty new scholars were admitted into the Program during the first semester of academic year 1980-81. Among them were two Nigerians and one Indonesian. The new scholars brought to 53 the number of students in the Program: 28 were on the senior level while 25 did their coursework.

Twelve students obtained the M.S. Fisheries (Aquaculture) degree during the first graduation exercises held on April 18, 1980 by the U.P. in the Visayas as an autonomous and distinct unit of the U.P. System. Three more completed the academic requirements for the degree at the end of summer 1980, while another three successfully defended their theses to complete the degree at the end of the first semester, AY 1980-81.

As of the end of 1980, 13 theses were being written; 12 are on-going studies; and two have been proposed and programmed for implementation starting early 1981.

Students of the UP-SEAFDEC Graduate Study Program monitor physico-chemical parameters in a brackishwater pond.

Institutional Linkages

Since it was established in 1973, the Aquaculture Department has been working closely with various national and international institutions towards the promotion of aquaculture research and development. The initial breakthrough in milkfish research would not have been possible without the continuing substantial support from the International Development Research Centre (IDRC) of Canada. Likewise, a good number of significant projects were implemented in the Seventies in collaboration with other institutions like Japan International Cooperation Agency (JICA), Oceanic Institute of Hawaii, Danish International Development Agency (DANIDA), Indian Council for Agricultural Research (ICAR), Tungkang Marine Laboratory, International Foundation of Science (IFS), the New Zealand Government, University of the Philippines, Philippine Council for Agriculture and Resources Research (PCARR), Bureau of Fisheries and Aquatic Resources (BFAR), and the private sector.

In 1980, more projects were initiated and/or implemented in cooperation with other institutions.

SEAFDEC-JICA

The services of the following Japanese aquaculture experts were extended: Shigeru Kumagai, until January 15, 1981; Hiroshi Motoh, until April 24, 1981; and Shiro Hara, until June 18, 1983. Mr. Yoshitetsu Nukiyama, Japanese visiting researcher on prawn hatchery, completed his six-year assignment with the Department in June 1980.

Mr. Haruo Nakajima, a Japanese expert in induced spawning of fish, participated in the spawning project of captive milkfish in tanks, from February 3 to May 3, 1980. Dr. Gunzo Kawamura, a Japanese sensory physiologist of larval fish, was assigned in Tigbauan from March 12 to May 11, 1980.

SEAFDEC-IDRC

Dr. T.J. Lam of the Department of Zoology, University of Singapore, participated in the IDRC supported milkfish maturation project of the Department from April to June 1980.

SEAFDEC-UNDP/FAO

The Department has been chosen as one of four lead centers in the Network of Aquaculture Centers in Asia. The other three are: the National Inland Fisheries Institute in Bangkok, Thailand; the Freshwater Aquaculture Research and Training Centre in Dhauli, Orissa, India; and the Integrated Fish Farming Research and Training Centre, WUXI, Jiangsu Province, China.

The Network was established as a result of the regional workshop on aquaculture planning in Asia organized by the UNDP/FAO Inter-regional Aquaculture Development and Coordination Programme (ADCP) in Bangkok in 1975 and endorsed by the Technical Conference on Aquaculture in Kyoto, Japan the following year.

While research activities will be the main focus in all lead centers, the Philippine Lead Center will be the headquarters for training of aquaculturists although part of the training program will be conducted at the lead centers in Thailand and India and, in subsequent years, also in China. The first training course under the program has been scheduled to begin in April 1981 at the Department's Tigbauan Research Station in Iloilo.

SEAFDEC-ARC

The Department was a recipient of training grants from the Artemia Reference Centre (ARC) for its staff to participate in the International *Artemia* training course at the State University of Ghent, Belgium.

ARC also made available the services of brine shrimp experts, Dr. Patrick Sorgeloos and Mr. Etienne Bossuyt who introduced cyst decapsulation and other *Artemia* culture techniques to Department researchers.

SEAFDEC-BELGIUM

Technical assistance from the Belgian Government in the form of a third country training grant was requested to enable the Department to offer a three-week regional training course on *Artemia* culture techniques.

SEAFDEC-DANIDA

Two Danish experts, Messrs. Flemming Petersen and Bent Nielsen, are presently undertaking research on limnology and fish production at the Binangonan Research Station. The Project, which started in January 1979, is part of DANIDA's two-year assistance to the freshwater aquaculture research program of the Department.

SEAFDEC-ODM

The Ministry of Overseas Development (ODM) of the United Kingdom supports a two-year research project on prawn pond culture. The project, which started in June 1979, is being implemented at the Leganes Research Station by Dr. James Norfolk, a British prawn culture biologist and marine resource expert.

SEAFDEC-SEARCA

Three seminar-workshops on Aquabusiness Project Development and Management or APDEM were held in 1980 in collaboration with the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA). A total of 130 participants from the Philippines and other countries completed the new training program.

SEAFDEC-BFAR

The joint project on freshwater fisheries technology verification/transfer and research was implemented by BFAR and SEAFDEC Binangonan Research Station. The project has two parts: additional field testing of *sugpo* cage farming in Laguna de Bay and other appropriate sites; and cooperative research on the farming of *sugpo* and other species in freshwater ponds.

SEAFDEC-TRC

A Memorandum of Agreement is being formulated by the Department and the Technology Resource Center (TRC), for the Technology Verification Project on Tilapia Cage Culture in Laguna de Bay.

Funding support shall be provided by TRC, while the Department will provide technical expertise and support services for the implementation of the project.

SEAFDEC-EDPITAF

The first national training seminar on brackishwater aquaculture management opened on October 1, 1980. The seven-week training is jointly sponsored by the Educational Development Program Implementing Task Force (EDPITAF), U.P.-Visayas College of Fisheries and the Aquaculture Department.

MAIN OFFICE
Tigbauan, Iloilo, Philippines
P.O. Box 256, Iloilo City

MANILA LIAISON OFFICE
6th Floor, Triumph Bldg., 1610 Quezon Ave.,
Quezon City, Philippines 3008
Telephone: 99-75-82
Cable: SEAFDEC Manila
Telex: 64145 SEAFDC PN